direct risk factors included in the stress test.[102]

(v) Additional Explanatory Variables Used in the Single Family Model

The following discussion addresses additional explanatory variables that are used only in the single family model. A list of additional explanatory variables for the multifamily model is provided after this discussion of single family variables. The variables discussed below help to complete or modify the basic option valuation for single family mortgages. The original LTV ratio helps to account for differences in default and prepayment rates due to borrower financial status. Occupancy status accounts for differences between single family owner-occupiers and investor-owners. Product-type factors adjust for differences that might be due to the unique risk characteristics of those products and the borrowers who use them. The yield curve slope accounts for different incentives to refinance between fixed-and adjustable-rate products. Some of the variables discussed below are used in statistical estimation of the models, but are represented by simplifying assumptions in the stress test.

(a) Original LTV Ratio

Original LTV ratio is used in the stress test as a proxy for a number of factors related to the financial status of single family borrowers that are recognized widely as influencing the propensity of borrowers to default. Among these factors, which were mentioned by ANPR comments, are borrower income, net worth, and debt burdens. Information about these factors is not available for most of the loans in OFHEO's database. A variable that is available as a proxy for relative financial status of borrowers is the original LTV ratio.[103] Both Freddie Mac and NAR recommended use of this variable. By making low down payments, high LTV borrowers signal that they are more likely to have few economic resources to finance the transaction costs of prepayment, or to endure spells of unemployment or other ''trigger'' events that might cause them to exercise their option to default. Also, high LTV borrowers demonstrate a willingness to ''leverage'' the financing of the home purchase, which may mean that they are more likely to exercise their default option when it is in the money. For these reasons, OFHEO found that original LTV is an important risk characteristic of mortgages, which OFHEO proposes to use both in estimating the single family model and in running the stress test.

(b) Occupancy Status

Historically, single family loans to owners who live in the collateral property have exhibited different performance than similar loans made to investors who rent the property. Difference in occupancy status is one of the loan characteristics that the 1992 Act specifically requires that OFHEO take into account in the stress test. It is also a distinction often made by the mortgage industry, because of a clear difference in the risks of borrower default or prepayment. Owner occupants are less likely than investors to exercise the default option because of the direct benefits occupants receive from the consumption of housing services. Also, owner occupants are more likely to prepay for non-financial reasons, such as residential mobility, than are investors.

The statistical equations used in the stress test were estimated with an investor loan indicator variable that captures the differential default and prepayment risk of these mortgages. However, to capture the differential risk of investor loans in the proposed stress test, OFHEO makes a simplifying assumption that investor loans are spread equally across all loan groups, according to their percentage in the overall Enterprise book of business, rather than creating separate loan groups for investor mortgages. For example, if investor loans are four percent of all loans for a particular Enterprise in a particular starting quarter for the stress test, then four percent of the loans in each aggregated loan group are presumed to be investor loans for purposes of running the stress test. The statistically derived investor-loan weighting factor (statistical coefficient) in each default and prepayment equation is then applied to the four percent figure to arrive at the differential investor loan risk for every loan group. Because investor loans are a small percentage of Enterprise single family portfolios and are heavily concentrated in the 70 to 80 percent LTV category, OFHEO's simplifying approach has no significant impact on loss rates.[104] The exact algorithms used in the proposed stress test to capture investor loan risk are detailed in section 3.5.2.3.2.5., Occupancy Status (OS), of the Regulation Appendix.

(c) Product Type

The 1992 Act expressly requires OFHEO to take differences in mortgage product type into account. In addition, because the benchmark loss experience was identified using the 30-year fixed-rate mortgage, it is necessary to reasonably relate the default experience of other types of mortgage products to the benchmark. Most commenters suggested some type of multiplier approach for other single family mortgage types that would measure the risk of these products in proportion to the risk of the benchmark loan type. OFHEO's proposed approach is broadly consistent with the thrust of these comments. Because comments received by OFHEO focused particularly on relating various mortgage product types to the benchmark experience, these comments are discussed later under section III.A.7.b., Relating Other Single Family Products to the Benchmark. This section discusses the way in which mortgage product type differences are handled in the single family mortgage performance model.

The stress test uses two primary sets of statistically estimated single family default/prepayment equations, one for fixed-rate and one for adjustable-rate mortgages. A third set of equations, which may be thought of as modified fixed-rate equations, is used to project the performance of less prevalent single family mortgage types relative to the performance of 30-year FRMs. This final set of equations includes as explanatory variables unique product-type indicators for 15-year fixed-rate mortgages, 20-year fixed-rate mortgages, balloon mortgages, FHA/VA-insured mortgages, and second liens. Description of these specific product-type variables and their derivations are included in section 3.5.2.3.2.8., Product Type Adjustment Factors of the Regulation Appendix and section IV.B.5.j., Product Type Indicators, of the Technical Supplement. Product type indicators allow estimation of multiplier-like effects using all available historical data, and they assure that measured differences in product-type

[102] Mortgage age combines with the constant term in the statistical default and prepayment equations to create what can be called ''baseline'' rates of default and prepayment: the time series of rates that would occur if all other influences were absent. Once variables representing those other influences are added to the equations, the actual patterns of default and prepayment rates can vary greatly from the baseline paths.

[103] Although credit scores could be a good indicator of the financial status of borrowers, as discussed below under section III. A. 5. e. vi. f., Credit Scores, their usefulness for developing and implementing a default/prepayment model in the stress test is limited because credit scoring is a fairly recent development in the mortgage industry.

[104] Loans on owner-occupied properties in the Enterprise portfolios also have a central LTV range of 70–80 percent. Thus, attributing some investor loans to higher LTV categories and some to lower categories, by assuming they have the same overall LTV distribution as do owner-occupied loans, has offsetting effects on predicted credit risk.

risk are consistent with the stress test environment. All products with variable payments over time are included as adjustable-rate mortgages. Other non-standard mortgage types, such as reverse mortgages and bi-weekly mortgages, are included with their fixed-rate counterparts with similar mortgage contract terms (length of mortgage in years).

As explained in section III.A.7.b., Relating Other Single Family Products to the Benchmark, some commenters were justifiably concerned that applying several product type multiples to a single loan would have an inappropriate compounding effect on default rates. OFHEO addressed these concerns in two ways. First, the multipliers were estimated in a multivariate statistical analysis within the default and prepayment probability equations, rather than applying fixed multipliers to estimated default rates for 30-year fixed-rate loans. This approach provides adjustment factors that are most consistent with broad historical experience and with the other risk factors in the model. By controlling for other explanatory variables, only the residual effects of the differences in product type are captured by these product-type adjustment-factor multipliers, which limits the size of their effects. Second, the models include all other explanatory variables as categorical variables (indicators of value-range categories), instead of as continuous measures of variable values. Using categorical variables helps control for unreasonable compounding risks, by preventing the combination of low house-price growth and sustained adverse interest-rate movements in the stress test to cause default rates to rise to unrealistic levels. For example, the stress test gives the same default weight to all probability of negative equity values above 35 percent, which effectively caps the influence of this variable in the stress test.[105]

(d) Yield Curve Slope

The slope of the Treasury yield curve is included as an explanatory variable in the prepayment equations. Both the choice between ARM and FRM loans and the timing of refinancing are influenced by expectations about future interest rates and differences in short-term and long-term borrowing rates associated with the slope of the Treasury yield curve. The slope of the Treasury yield curve is measured in the proposed stress test by the ratio of the ten-year CMT to the one-year CMT. A high value for the slope of the yield curve indicates that short-term rates are low relative to long-term rates. A high value, therefore, reduces the likelihood that ARM borrowers will refinance into fixed-rate mortgages, and increases the likelihood that fixed-rate borrowers will refinance into ARMs to take advantage of the more attractive interest rates.

(e) Burnout

For single family mortgages, the proposed stress test uses the variable burnout to capture the effect of the inability of borrowers to refinance their mortgages due to equity or other credit constraints. Burnout is the adverse selection that occurs when borrowers retain their mortgages during periods when there are clear financial benefits to refinancing. In this context, adverse selection is reflected in the lower average credit quality of mortgages remaining in a pool after a significant refinancing opportunity, compared to the overall quality of the mortgages in the original, larger pool. Adverse selection occurs because borrowers and properties with higher credit quality refinance in higher proportions than do those with lower credit quality. The remaining mortgages, therefore, will experience higher conditional default rates. Accounting for this change in the underlying quality of a mortgage pool is preferable to using only a prepayment-option-value variable in predicting defaults, principally because its effect continues unchanged over time. The burnout variable in the stress test indicates whether, over the previous eight quarters of mortgage life, there have been at least two quarters with significant refinance opportunities, as defined by a two percentage point difference between the mortgage coupon rate and the market interest rate on fixed-rate mortgages.

For similar reasons, burnout is also included as an explanatory variable in single family prepayment equations, although its effect is in the opposite direction to that in the default equations. As discussed in the ANPR, burnout suggests that prepayment rates will be less responsive to interest rate changes after a pool of mortgages has already undergone a significant period of refinance opportunities.

(vi) Single Family Variables Not Used in Running the Stress Test

Addressed below are several variables suggested by ANPR commenters that either are not used in the single family default/prepayment model, or were included in the statistical estimations but are represented by fixed or constant values when the stress test is run. In general, to estimate the model, OFHEO used variables that had significant independent effects on default and prepayment rates. However, OFHEO does not propose to use all of these variables in running the stress test. Some variables are not used in the stress test because they would diminish the role of the benchmark loss experience in determining stress test credit risk. Others were not needed to reflect statutory requirements to distinguish among loan types and characteristics, or between the effects of the up-rate and down-rate scenarios. Allowing such variables to vary in value in running the stress test would create credit-risk dimensions that are unnecessary and not contemplated by the statute.

(a) Relative Loan Size

Relative loan size[106] is the ratio of the original loan amount to the average-sized loan purchased by the Enterprises in the same State and in the same origination year. This variable was included when estimating the statistical model to isolate differences in the performance of loans of above and below average size, but is not used in the stress test.

As suggested by NAR, OFHEO explored the different default propensities of loans with high and low balances using Enterprise data. OFHEO's use of a relative loan size variable in the statistical estimations of the single family model demonstrated that relatively larger loans tend to have higher prepayment speeds, but differences in default rates by loan size were small and inconsistent. OFHEO interprets the faster prepayment speeds of relatively large loans as reflective of the higher dollar value of the prepayment option on these loans. Households with relatively large loans may also have higher overall debt burdens and be more responsive to opportunities to refinance debt so as to lower payment burdens.

The stress test does not use relative loan size as a variable, because it is not needed to reflect statutorily required distinctions, and including it as a variable would have necessitated a sevenfold increase in the number of loan group records in the stress test. OFHEO believed that the benefit derived

[105] The number of loans in the historic sample used to estimate the statistical model of default and prepayment rates gets very small as the value of the probability of negative equity rises much above 35 percent. OFHEO therefore does not believe that there is valid information on default risk that could be gained by allowing for categories of probability of negative equity above, for example, 50 percent.

[106] Relative loan size should be distinguished from the actual original and current dollar balances of the loans, which are included elsewhere in the stress test.

did not justify the additional complication of the stress test that would result. As a result, all loans are put into the ''average'' size category for this variable when running the stress test.[107]

(b) Season of the Year

The season (quarter) of the calendar year was included when estimating the statistical model to account for the potential impact of weather, school schedules, and seasonal employment patterns on residential mobility and default and prepayment. In order to avoid seasonal variation in the quarterly risk-based capital requirements when the model is applied in the proposed stress test, an average of the season of the year effects is used. Because of the actual statistical technique used to estimate the equations, this average effect is obtained by excluding the season-of-year variable from the stress test default and prepayment equation.[108]

Use of seasonal variation was mentioned by Freddie Mac as a weakness of the termination models used by investment banks to value mortgage backed security pools. OFHEO agrees with Freddie Mac that such seasonal variation would complicate the stress test, by creating quarterly volatility in loss rates, with no particular safety and soundness benefit.

(c) Origination Year

Freddie Mac and NAR recommended including origination year as a variable. This approach would capture differences in the performance of specific mortgage origination cohorts due to excluded factors such as regional income growth and unemployment, or changes in mortgage underwriting standards over time. OFHEO considered using this variable but found that origination year is not an inherent risk factor, is not needed to reflect the types of distinction required by the 1992 Act, and is incompatible with the requirement to relate stress test losses to the benchmark loss experience. The last point is most important. The benchmark loss experience captures loans with the worst origination year and the worst credit risk profile. Assigning to loans originated in a given year a unique underlying credit profile, which may be different from the benchmark credit profile, would remove an important element of the link between stress test losses and the benchmark loss experience. In addition, varying inherent credit risk by loan origination year would require speculative assumptions about loan quality for more recent origination years for which no credit-risk track record has yet been established.

By not including origination year as an explanatory variable, the statistical equations capture average origination-year profiles of default and prepayment. As discussed later under in section III.A.7., Relating Losses to the Benchmark Loss Experience, these profiles are adjusted further to reasonably relate starting loan portfolios to the benchmark loss experience. If the stress test were to allow for origination year differences when estimating the statistical equations, it would be necessary to assign the benchmark origination year effect to all loans in the stress test to preserve a reasonable relation to the benchmark loss experience. This approach would complicate the stress test without changing the results that are obtained using the proposed approach.

(d) Unemployment

Unemployment rates were listed by some commenters as a possible explanatory variable. For numerous reasons, OFHEO does not propose to include unemployment as a variable either in running the stress test or in estimating the statistical model. OFHEO does not propose to include unemployment rates as an explanatory variable in the stress test, primarily because it is not a loan characteristic, but a macro-economic variable, and it is not one of the economic variables specified in the 1992 Act. In any event, the effect of economic-condition variables not specified in the statute, such as unemployment, are captured in the stress test by relating the stress test to the actual benchmark loss experience, because the appropriate values are inherent in that experience. Thus, reasonably relating the stress test to the benchmark loss experience, as described in the next section, captures the strenuous economic conditions required by the 1992 Act without adding more economic variables. Minimizing the number of variables used to define economic conditions is responsive to the comments of both Fannie Mae and Freddie Mac, who argued against unnecessary complexity.

(e) Purchase vs. Refinance Loans

MRAC suggested that OFHEO take loan purpose into account. OFHEO considered whether this distinction should be included as a variable, but has proposed a stress test that does not distinguish between loans made for the purpose of purchasing and loans made for the purpose of refinancing property. OFHEO has found insufficient basis to distinguish between the risks of loans for purchases and loans for refinancing. Furthermore, OFHEO prefers not to create capital incentives based on loan purpose, except as required by statute (e.g., the occupancy status distinction).

(f) Credit Scores

OFHEO does not propose to follow the recommendation of MRAC to use mortgage borrower credit quality considerations as explanatory variables. OFHEO is aware that the mortgage industry is moving toward risk-based loan pricing based, in part, on mortgage credit scores that rely heavily on borrower credit ratings.[109] OFHEO is studying the use of credit scores by the Enterprises, and the potential for impact on stress test credit losses, but does not believe that it is appropriate to consider these in the stress test or to use them to estimate the models. First, it would be difficult, if not impossible, to reasonably relate credit risk differences based upon credit scores to the benchmark loss experience, because credit-scoring data are not available for benchmark era loans.[110] Second, the proposed stress test is designed to reasonably relate starting the performance of mortgage portfolios to the benchmark loss experience based upon loan characteristic differences referenced in the 1992 Act, which do not include measures of borrower creditworthiness.[111]

[107] This value is part of the fixed-factor terms reported in section 3.5.2.3.3., Combining Explanatory Variables and Weights of the Regulation Appendix for each default and prepayment equation. Relative loan size is discussed in section B.5.i., Relative Loan Size of the Technical Supplement.

[108] Seasonal variation is discussed in section B.5.g., Season of the Year, of the Technical Supplement.

[109] The most widely used measure of borrower creditworthiness is a composite score developed by Fair Isaac Corporation, commonly referred to as a ''FICO score.''

[110] Archives at the credit repositories only go back to the late 1980s, and, even there, records are not complete.

[111] The fact that OFHEO does not consider differences of credit risk by credit scores in the proposed stress test does not limit the ability of the Enterprises to to make use of credit scores. The Enterprises may further stratify the risk classifications used by OFHEO in the proposed stress test, for purposes of internal capital allocation and guarantee pricing. For example, after determining the required regulatory capital for a particular product class the Enterprises may, if they choose, allocate the required capital among purchases of that product according to borrower credit scores, for internal purposes. Thus, the dimensions on which the Enterprises choose to develop risk-based guarantee pricing are not limited by stress test risk classifications.

(vii) Additional Multifamily Explanatory Variables

Understanding the choice of explanatory variables for the multifamily default/prepayment model requires understanding the way in which default and prepayment equations are organized. The stress test uses two default equations, to distinguish between different multifamily lending programs, and five prepayment equations, to distinguish between different product types. The multifamily model allows these various default and prepayment equations to interact with each other to provide appropriate default and prepayment rate projections for all multifamily loans, throughout the stress period.

One of the two default equations is for purchases of newly originated loans (cash purchases),[112] and the other is for negotiated swaps of seasoned loan pools for mortgaged-backed securities (negotiated purchases). This separation allows the stress test to account for differences in loan quality across the two programs. The Enterprises may take lower quality loans and properties in their negotiated purchase programs than in the cash purchase programs, but require significant credit enhancements from the seller/servicers to compensate.

The five prepayment equations used to accommodate product-type and product life-cycle differences allow the proposed stress test to account for the effects of loan characteristics, such as yield-maintenance provisions,[113] adjustable interest rates, and balloon terms. It is more important to capture the unique features of balloon mortgages in the multifamily business than it is in the single family business because balloons make up the majority of multifamily portfolios. The five prepayment equations are for: (1) All fixed-rate loans in the yield-maintenance period; (2) fully-amortizing fixed-rate loans after yield maintenance requirements; (3) fixed-rate balloon loans after the expiration of yield-maintenance requirements (but prior to maturity); (4) all ARM loans (prior to maturity for balloon ARMs); and (5) all balloon loans (with fixed or adjustable interest rates) at and after the maturity year.

To see how these prepayment equations work together, note, for example, that fixed-rate balloon loans have three relevant time periods: first is ''in-yield maintenance,'' the time when the yield maintenance terms apply; second is ''post yield maintenance,'' the period after the yield maintenance term expires and prior to loan maturity; and third is ''post-balloon,'' the period starting when the loan is due in full.[114] For loans that extend to and beyond the balloon point,[115] OFHEO proposes a separate prepayment equation, which is referred to as a ''payoff'' equation because it is no longer possible to ''prepay'' loans on or after the balloon date.

(a) Explanatory Variables in the Two Multifamily Default Equations

The two multifamily default equations are similar except in two respects. First, the equation for cash purchases makes adjustments for loans purchased in original multifamily programs to distinguish them from more recent programs. Second, the negotiated purchase loan equation has an adjustment factor for loan programs that obligate the seller to repurchase loans when they are delinquent for 90 days. These distinctions will be discussed in the context of each explanatory variable.

(1) Joint Probability of Negative Equity and Negative Cash Flow

As with single family loans, one of the most important factors affecting multifamily loan default is borrower equity. When the value of the property is less than the value of the mortgage, the borrower, by defaulting, can effectively ''sell'' or ''put'' a mortgage back to a lender at the value of the underlying property. However, as recognized by the ANPR commenters, there is a second consideration for commercial properties (including multifamily properties)—cash flow from the property. Even though equity is zero or negative, the borrower does not have an economic incentive to default as long as cash flows are positive.

The stress test includes a default option valuation variable that allows for consideration of the cash flow position of the property, while also considering the borrower's equity position. A value for this variable, referred to as the joint probability of negative equity and negative cash flow, is calculated for each loan in each observation period. It measures the potential value of ''putting'' the mortgage to the lender and investor through default, given that both equity and cash flow are important.[116]

As shown in section D. 4. a. i., Joint Probability of Negative Equity and Negative Cash Flow, of the Technical Supplement, the joint probability of negative equity and negative cash flow for a project is the probability of having both LTV greater than 1.00 and DCR less than 1.00. The proposed stress test uses loan amortization schedules, rental inflation, vacancy rates, and interest rates to update LTV and DCR, which are then used to update the joint probability variable values.

(2) Original Versus Current Loan-Purchase Programs

OFHEO faced the issue of what, if any, adjustment should be made in the model to distinguish between loans purchased under original cash-purchase programs (purchased pre-1988 for Fannie Mae and pre-1992 for Freddie Mac) and current programs. As noted by Freddie Mac, the Enterprises computed both DCR and LTV differently for loans purchased under original programs than they compute those ratios today for current purchase programs. OFHEO recognizes that in the 1980s it was a common appraisal practice to adjust actual rents (and therefore net operating income) upward by an estimate of annual inflation and to use optimistic vacancy rate assumptions. This practice resulted in an overstatement of actual DCR and LTV values at the time of loan origination. Current practice does not allow for such inflation adjustments of projected rents, and factors minimum levels of anticipated vacancies into property valuation, even if the property is fully rented at the time of loan origination.

In addition to the overstatement of net income, original multifamily cash-purchase programs at the Enterprises had other significant weaknesses perhaps because the Enterprises only began purchasing conventional multifamily loans in 1983 and did not have experience with the differences from single family lending. Even controlling for the overstatement of rents and for changes in tax laws in 1986 that depressed real estate values, these weaknesses led to extraordinarily high loss rates. OFHEO views these large losses, to a large extent, as nonrecurring startup costs attributable to

[112] Cash-purchase programs may involve delivery of loans for cash or for mortgaged backed securities. They are called ''cash'' programs because they involve the purchase of individual loans under published underwriting guidelines and pricing.

[113] A yield maintenance provision permits prepayment, but requires the borrower to pay penalties to compensate the lender or investor for lost interest until the yield maintenance period expires.

[114] Balloon loans with adjustable interest rates (rather than fixed coupon rates) do not have yield maintenance terms, so they only have two relevant periods—pre- and post-balloon.

[115] After the balloon maturity date, the Enterprises may permit loan extension.

[116] The equity and cash flow positions of a property are positively correlated. The joint probability of negative equity and negative cash flow variable used in the proposed stress test captures this relationship.

inefficiencies involved in learning a new business. For these reasons, OFHEO believes that the Enterprises' multifamily lending programs in the early and mid-1980s are so different from the current programs that it would be inappropriate to consider those early loans to be the same type of mortgage product as the multifamily loans that are made today.

The stress test accounts for the difference in the older loan programs and the newer programs in two ways. First, the stress test adjusts the origination DCRs and LTVs of original cash purchase loans to remove the estimated annual inflation factors and restate those ratios as they would be calculated by the Enterprises in their current program purchases.[117] Second, the stress test includes a variable in the default equation that distinguishes between original and current cash purchase programs. This variable results in higher levels of default on original cash purchase loans than on newer loans.

A significant consideration in OFHEO's proposal to distinguish the original cash purchase loans from loans purchased under current programs was that failing to make that distinction would create a relatively more severe (and far less) loss experience for multifamily loans than the benchmark loss experience creates for single family loans.[118] In OFHEO's view, imposition of such extreme levels of default upon the Enterprises' multifamily loans would be contrary to the intent of the 1992 Act that rates of default and severity be ''reasonably related'' to the benchmark loss experience. It is also possible that basing stress test losses on average default rates of original cash-purchase loans would result in an implied marginal capital requirement so high as to create an inappropriate disincentive to engage in new multifamily lending.

(3) Depreciation Write-offs and Tax Law Changes

In the absence of a price index for multifamily properties, the stress test captures most of the changes in property value by updating DCR and LTV according to changes in rents, vacancies, and interest rates. However, changes in DCR and LTV that are due to other factors are not captured in these procedures. The most important missing factor is the tax benefit afforded to owners of investment real estate through depreciation write-offs. ACB commented that depreciation allowances have important effects on property cash flows. OFHEO recognizes this fact and that the allowances also have important effects on capital gains at the time of property sale. The tax value of depreciation write-offs significantly influences the return from multifamily property investments and, consequently, the default risk of multifamily mortgages.

OFHEO agrees with Freddie Mac that tax law changes affecting multifamily default rates during the 1980's should be taken into account, but that OFHEO should not speculate on the effect of potential legislative or other governmental actions during the stress period. The proposed stress test incorporates an index that measures the value of depreciation write-offs for a new investor. It measures changes in quality due to changes in write-offs and allows OFHEO to reflect the effects of such changes on mortgage defaults historically. The actual index value used in the stress test is an approximation of expected values throughout the stress period.[119] It is calculated based on depreciation rules and tax rates as they existed in 1997, with no adjustments for movements in interest rates since that time, or for the interest-rate shocks that will occur in the stress test. The tax rules governing depreciation allowances have the largest impact on the value of this variable. These rules changed significantly in 1986, but have not changed significantly since. Because the historical database included many loans originated before the tax rule change, OFHEO allowed the value of this explanatory variable to vary for purposes of estimating the statistical equations for multifamily mortgage default. However, due to the subsequent stability in those rules, OFHEO proposes to hold the value of this variable constant throughout the stress test. If the applicable tax rules change in the future, or if OFHEO believes that there are other reasons for either changing the specified value for the stress test or allowing its value to change throughout the stress test, OFHEO will initiate a new rule making process. However, as recommended by Freddie Mac in its ANPR comments, OFHEO will not speculate about tax law changes that might occur during the stress period. Due to data restrictions, the depreciation-allowance is only included in the cash-purchase default equation.[120]

(4) Loan Programs with Seller/Servicer Repurchase Features

Some Enterprise multifamily loan programs require seller/servicer repurchases of loans that become 90-days delinquent. For these programs a 90-day delinquency event is effectively a default, while for all other loans, default means a property loss event (short sale, note sale, third-party sale or foreclosure). To account for this difference when estimating the statistical model, OFHEO applied, as an explanatory variable, the ratio of 90-day delinquencies to full defaults. This treatment is important because the rate of 90-day delinquency events is always higher than the default rate for property loss events, and the loss severity for 90-day delinquencies is lower. By including this ratio, and thus including loans with the 90-day delinquency terminations, OFHEO was able to estimate a negotiated-purchase default equation based on a much larger data set than would have been possible otherwise.

(5) Balloon and ARM Payment Shock Risk

Following HUD's suggestion, OFHEO analyzed defaults of Enterprise balloon loans at the balloon point. As a result, OFHEO proposes to give additional weight to the joint probability of negative equity and negative cash flow variable for balloon loans that survive to the year of balloon maturity. This extra weighting takes into account the increased risk that mortgages with weak financials will default as the balloon point approaches. Also, interest rate movements may create payment shock (change in the periodic mortgage payment) in the post-balloon period, which affects the probability of default. The stress test accounts for the effect of

[117] OFHEO found that loans acquired in negotiated swap arrangements in the early and mid 1980s were highly seasoned and had low default rates. They therefore did not appear to include the inflation factor evident in cash purchases. Therefore, OFHEO does not adjust DCRs and LTVs for loans in negotiated purchase pools.

[118] The relationship of multifamily default rates to the benchmark experience is discussed later in section III. A. 7. c., Relating Multifamily Mortgage Performance to the Benchmark.

[119] The stress test does not capture actual depreciation allowances for borrowers. Enterprise databases do not include the year of property purchase. Therefore, the exact depreciation rules affecting cash flows and investment value to existing owners are unknown. Even on newly constructed projects, the Enterprises generally do not purchase the mortgage until target occupancy rates are met, which may be some time after origination. For these reasons, it would be extremely difficult to determine the actual value of depreciation write-offs to current owners. Although the value to current owners affects the owner's cash flow, the value to potential purchasers (which would be based upon current appreciation rules) affects property value and the owner's equity in the property. Therefore, this explanatory variable for depreciation write-offs helps to reflect more accurately the true LTV of the mortgage.

[120] See section D. 4. a. ii., Construction of the JPt Variable of the Technical Supplement for details.

this shock directly through adjustments to effective DCR in the post-balloon period. These adjustments then affect the joint probability of negative equity and negative cash flow, reflecting the fact that the decision to default or payoff is no longer a function of the original mortgage coupon rate, but of the prevailing market rates at the time of balloon expiration. In sum, the stress test reflects that the value of the default (''put'') option, as measured through the joint probability variable, becomes more significant for default rates in the post-balloon period because there is increased pressure on the borrower to either default or refinance the property.

ARMs also experience payment shock because of changes in market interest rates. ARM payment shock occurs periodically during the term of the loan, and ARMs continue to amortize after the payment shock, according to the original contract term. The ARM prepayment equation in the stress test accounts for these periodic changes in interest rates. In contrast, the payment shock for a fixed-rate balloon loan does not occur until the balloon point. Some loans in Enterprise portfolios are ARMs with a balloon maturity. These loans have payment shock every year and also at maturity. The proposed stress test models the annual changes in their DCRs resulting from changes in mortgage coupon rates and then adds an additional balloon shock through the additional weight given to the joint probability variable in the post-balloon period.

(6) Loan Size

The stress test does not include a variable for loan size. S&P explained that it bifurcates commercial loan pools into two parts to calculate credit loss potential—the largest loan, and all other loans in the pool. S&P assumes 100 percent risk of default on the largest loan and average risk of default on the other loans. This approach is designed to recognize the uneven dollar credit loss risk inherent in pools that contain loans that are large relative to the total size of the pool. Credit risk for the pool is then estimated by S&P to be the sum of estimated credit risk on each part. S&P did not specifically recommend that OFHEO adopt this approach in the stress test.

OFHEO agrees that S&P's methodology is appropriate for analyzing differential impact of large and small loans on potential credit losses in mortgage security pools. However, no one multifamily loan default could have a significant impact on total losses or capital for either Enterprise. For that reason, OFHEO decided not to propose any measure of loan size as an explanatory variable in the multifamily default/prepayment model.

(b) Explanatory Variables in the Five Multifamily Prepayment Equations

As explained above, the multifamily model uses five loan prepayment equations to identify unique product type and life-cycle characteristics. This approach is consistent with Freddie Mac's and MRAC's comments on accounting for mortgage product types and terms in the default and prepayment models. There are some differences in explanatory variables across these five equations, which are discussed below.

(1) Prepayment Option Value

As discussed earlier, OFHEO proposes to use the relative interest rate spread to measure the prepayment option value (mortgage premium value) for prepayments. The relative spread is the ratio of the difference between the coupon rate and the current market interest rate to the coupon rate. To account for the asymmetry of effects from increases and decreases in interest rates, the spread is split into two variables.[121] One is active if current market interest rates are above the mortgage coupon rate, and the other is active if current market rates are below the mortgage coupon rate. Decreased interest rates increase refinancing speeds. Increased interest rates decrease both normal refinancings and cash-out refinancings. Cash-out refinancings are refinancings in excess of the outstanding indebtedness. They are used to achieve a desired debt-to-equity ratio in the property as explained below in the discussion of current LTV. Relative spread variables appear in all prepayment equations except for the balloon and post-balloon payoff equations. At balloon maturity, all spreads become irrelevant, because borrowers are contractually obligated to pay off or refinance the property.

For the ARM prepayment equation, the relative spread variable is calculated by comparing the coupon rate to the current market rate on fixed-rate loans, rather than to the market rate for ARMs. This approach accounts for any incentive to refinance into a fixed-rate loan. Because there are no yield-maintenance terms or special incentives to refinance ARM loans when interest rates fall, the stress test includes one spread variable that captures both increases and decreases in interest rates. In addition, the stress test does not distinguish between life-cycle periods for ARMs; just one prepayment equation is estimated.

(2) Current LTV

Another important issue in modeling multifamily loans is the propensity of investors in multifamily properties to refinance mortgages over time to increase their debt (leverage) ratios, and thus increase returns on invested equity.[122] To capture the borrowers' ability to qualify for a new loan and the incentive to adjust debt-to-equity ratio, the proposed stress test includes current LTV as an additional explanatory variable. If the current LTV falls, investors have more incentive to prepay and are more likely to find a lender willing to refinance the property.

(3) Prepayment Option Value in the Yield-Maintenance Period

During the yield-maintenance period, borrowers may prepay, but they must continue to provide the contractual yield until the yield-maintenance period expires. Thus, a prepayment in the yield-maintenance period can be expensive, particularly in the early years of a mortgage. The more years to go in the yield-maintenance period, the greater the fee.[123] To capture the declining financial cost of prepayment throughout the yield-maintenance period, OFHEO proposes a variable measuring years remaining until the end of the yield-maintenance period. This variable appears in the prepayment equation for fixed-rate loans in the yield-maintenance period.[124]

(4) Prepayment Option Value in the Pre-Balloon Period

During the pre-balloon period, borrowers are uncertain about the level of market interest rates at the future balloon point. Hence, borrowers may be willing to pay in order to lock into a favorable interest rate, rather than take

[121] Such explicit bifurcation is not required for the single family prepayment equations because the categorical nature of the spread variable used there allows for asymmetric effects.

[122] *See* Jesse M. Abraham and H. Scott Theobald, ''Commercial Mortgage Prepayments,'' in Frank Fabozzi and David Jacob, *The Handbook of Commercial Mortgage-Backed Securities*, New Hope, PA: Frank J. Fabozzi Associates, 55–74 (1997).

[123] Because this effect runs counter to the effect of the call option value, OFHEO researched the possibility of a joint effect of the years-to-go and the rate drop variables. The fixed effects of the years-to-go variable proved to be a better predictor of actual, historical prepayments during yield maintenance periods.

[124] For loans with true prepayment prohibitions, or ''lock-outs,'' the variable is set equal to the maximum number of lockout years throughout the lockout period. *See* section 3.5.4.3, Procedures, of the proposed Appendix to 12 CFR part 1750, subpart B for details.

their chances with possible adverse interest rate movements. This risk aversity with respect to interest rate movements prior to the time of balloon maturity gives rise to an additional financial value from early prepayment. OFHEO proposes two explanatory variables to capture the effect of risk aversity on prepayment rates in the pre-balloon period. They measure the additional effects of the primary prepayment option variable-relative spread-when it is in the money (market interest rates are lower than the mortgage coupon rate).

The first variable provides an additional effect for interest rate drops in the year immediately prior to the balloon year, and the second provides for a separate, additional effect for interest rate drops in the second year prior to the balloon year. These two variables allow for increased incentives to refinance if the prepayment option is in the money in the period leading up to balloon expiration. They capture the risk aversity of borrowers with respect to future interest rate changes as balloon maturity approaches.

(5) Balloon and Post-Balloon Payoffs

HUD commented that OFHEO should model the value of the refinancing option at the balloon point on balloon mortgages because the lender often has a contractual obligation to refinance at the borrower's option. OFHEO agrees that payoffs at the balloon point are different from prepayments before the maturity date, but has found that the lender generally does not have an unconditional contractual obligation to provide new funding if the borrower requests it. Payoff of the balloon loan (generally by new borrowing to refinance the property) is contractually required at term. If the borrower is successful at finding new financing at that point, the event that appears in Enterprise records is a payoff of the original loan and not a prepayment. Despite the contractual requirement of balloon payoff, not all loans terminate at the balloon point.[125] Generally, balloon loans are extended beyond the maturity date because, although the property has weak financials, lenders are unwilling to initiate foreclosure on loans that have been making payments at the original coupon rate. To capture the ability of multifamily borrowers to obtain new loans at balloon expiration, and, therefore, to pay off the original mortgage, the model includes a variable similar to the joint probability variable used in the default equations—the joint probability that current DCR and LTV values are sufficient to qualify for a new mortgage. This is the only variable used in the pay-off equation for balloon mortgages, and it is based on minimum qualification criteria for multifamily mortgages, LTV ≤ 0.80 and DCR ≥ 1.20.

(6) Effect of Fixed-Rate Loan Interest Rates on ARM Prepayments

A final variable included in the ARM prepayment equation is the market rate on fixed-rate loans. This variable accounts for incentives to refinance ARM loans into fixed-rate loans to avoid future uncertainty regarding interest rate movements. If the FRM rate is high, borrowers expect interest rates to drop in the future and are likely to delay prepayment of ARMs. Likewise, when interest rates are low—regardless of the spread between FRM and ARM rates—there is an incentive to refinance into a fixed-rate product to avoid potential increases in future interest rates.

6. Loss Severity

Loss severity is the net cost to an Enterprise of a loan default. The three major cost categories are loss of loan principal transaction costs at both foreclosure and disposition, and asset funding costs throughout the process. The net cost is determined by crediting against these costs the revenues associated with the defaulted loan. The major revenues are proceeds from the property sale and from mortgage insurance or other forms of credit enhancement.

In determining how to model loss severity in the stress test, OFHEO considered the following issues:

1. what general approach to take in modeling loss severity,

2. whether the stress test should model individual cost and revenue elements of loss severity or model severity as one single measure,

3. what explanatory variables should be included explicitly in modeling loss severity, and

4. an appropriate house price index for real estate owned (REO) properties.[126]

a. General Approach to Modeling Loss Severity

In the ANPR, OFHEO discussed four general approaches to estimating the separate effects of explanatory variables on loss severity. One approach is to use a multivariate statistical model to estimate the separate effects of explanatory variables on total loss severity rates. A second approach is to use statistical models relating the individual elements of loss severity to explanatory variables. A third approach would set fixed parameters for the elements of loss severity (foreclosure costs, carrying costs, and sales prices), while allowing final loss severity rates to vary based on other factors such as the presence of private mortgage insurance. A fourth, relatively simple approach would be to assume that all defaulted loans face a fixed and equal level of loss severity.

(i) ANPR Comments

ACB and MRAC encouraged OFHEO to use a multivariate statistical model of loss severity. ACB, apparently assuming the stress test would include a statistical model of defaults, stated that ''[i]t is not a rational allocation of resources to develop a sophisticated model of mortgage defaults and then to apply a rule-of-thumb percentage to the unpaid principal balances.'' S&P described its use of data from the Great Depression as the basis for stress tests it uses to rate single-family mortgage pools. Freddie Mac recommended that OFHEO use average loss severity rates from the benchmark loss experience, adjust them to account for the stress test interest rate environment, and apply additional adjustments for various property types.

(ii) OFHEO's Response

OFHEO believes that a statistical model is the best approach to take into account loan seasoning and the dynamic nature of economic changes in the stress period. OFHEO agrees with ACB that it would be inappropriate to develop a sophisticated default model and then to apply a rule-of-thumb percentage to the UPB to determine loss severity. At the same time, OFHEO recognizes that developing statistical models of each loss element is unnecessarily complex. Based on its analysis of the available information, OFHEO proposes a two-part model for single family loss severity: a statistical equation for loss of loan principal and fixed parameters for the other cost elements. Specifically, the statistical model developed by OFHEO estimates loss of loan principal as a function of loan seasoning-updating the original LTV using HPI growth rates and loan amortization. For multifamily loss severity, OFHEO proposes to use only fixed cost element values. The rationale for this is explained below under section III. A.7., Relating Losses to the Benchmark Loss Experience.

[125] *See* Elmer and Haidorfer, ''Prepayments of Multifamily Mortgage-Backed Securities,'' *The Journal of Fixed Income*, March 1997, 50–63 (pointing out that not all loans terminate at balloon point); Abraham and Theobald, op. cit. (referring to this phenomenon as extension risk). OFHEO confirms the existence of post-balloon loans in Enterprise portfolios.

[126] REO properties are properties acquired as a result of foreclosure or similar action.

The approach outlined by S&P would not be appropriate for OFHEO's stress test because it does not adjust for loan seasoning or provide for a reasonable relationship to the benchmark as required by the 1992 Act. However, consistent with the S&P approach, the stress test does provide for a greater than average drop in house prices for foreclosed properties. As discussed below, under section III. A.6. b., Elements of Loss Severity Modeled, the stress test uses a statistical equation to model the expected decline in values on foreclosed properties, which will be greater than the decline in property value associated with HPI assumptions used in the stress test. In addition, as discussed later under section III. A.7., Relating Losses to the Benchmark Loss Experience, the stress test adds an extra loss factor to relate stress test property value loss to the actual experience of the four-State benchmark.

OFHEO agrees that Freddie Mac's recommended approach is simpler than using a statistical model. However, an empirically based statistical model is more versatile and flexible, allowing the stress test to reflect loss severity rates appropriate for each Enterprise's mix of loans and the stress test interest rate environment. OFHEO proposes a hybrid approach that retains the simplicity of fixed cost factors for most severity elements, while developing a more sensitive measure of property value, the element most affected by pre-stress test loan seasoning.

OFHEO does not propose at this time to take property type differences into account in stress test loss severity rates, as suggested by Freddie Mac. Although OFHEO finds higher loss severity rates for investor-owned properties, accounting for this effect would increase significantly the number of loan group records used for starting books of business in the stress test. Given the small percentage of Enterprise portfolios that investor-owned loans comprise, OFHEO felt that the added complexity was not justified by the benefits of calculating severity rates for owner-occupied and investor-owned single family loans separately. Therefore, OFHEO does not propose to apply risk multiples for investor-owned properties in determining loss severities. Rather, the single set of cost elements used in the stress test are determined by Enterprise experience with all single family property types combined.

b. Elements of Loss Severity Modeled

In addition to asking whether OFHEO should use a statistical model of loss severity, the ANPR asked whether the stress test should model loss severity as a single value or model the various cost and revenue elements of severity separately.

All ANPR commenters favored, at varying levels, an element-by-element analysis. The VA recommended that the stress test model the amount and timing of both the cost and the revenue elements of loss severity to provide more accurate estimates of Enterprise cash flows. HUD recommended that the loss severity model include certain individual cost elements, all of which would be valued separately by the proposed severity module. NAR stated that ''the modeling of loan loss severity should only include those factors that are independent of incidence of default'' and emphasized the importance of modeling time in default separately. In contrast, Freddie Mac stated that defaults and severity are products of the same underlying characteristics and economic factors. Freddie Mac suggested that stress test severity calculations differentiate loans by original LTV and coupon class and by product type distinctions. In addition, Freddie Mac favored using the rate of loss of principal balance from the benchmark loss experience.

ACB supported using a sophisticated model of loss severity, which would, presumably, require breaking down severity into its constituent parts for analysis and modeling. MRAC suggested separate analysis of the elements of loss severity, including the estimated sale proceeds, holding time, monthly holding costs, and costs of sale.

OFHEO agrees with the commenters that the stress test should model individual cost and revenue elements separately, rather than model them together as a single cost category. Such an approach allows the stress test to model the interrelationship of those elements that significantly effect loss severity. Accordingly, OFHEO proposes to model elements in three principal groupings: (1) loss of loan principal balance, (2) transaction costs (e.g., expenses related to foreclosure, and property holding and disposition expenses), and (3) funding costs on non-earning assets. OFHEO believes that measuring elements in these groupings is necessary to accommodate differences in the timing of various elements of loss severity and differences in the pre-stress test seasoning of loans. Each cost or revenue factor is applied at one of the following three points in time (each in terms of months from date-of-default): time of loan repurchase (for loans in security pools) or bad-debt write off (for retained loans); time of foreclosure completion; and time of foreclosed property disposition.

In addition, consistent with Freddie Mac's comment, OFHEO's proposed loss severity calculations differentiate by LTV and coupon class. They also include product distinctions where those distinctions involve FHA/VA insurance, interest rates and amortization terms. The amount of the loss of loan principal balance is sensitive to loan amortization. Because 15-year mortgages amortize relatively early and more quickly, their predicted losses are much less than those on otherwise comparable 30-year mortgages.

(i) Loss of Principal Balance

A critical element of loss severity is loss of loan principal balance, i.e., the difference between the outstanding principal balance on the loan at the time of default and the sale price of the foreclosed property. This loss occurs because of general declines in local housing values, the depreciation of the individual property, and/or discounts required to sell properties with ''foreclosure'' labels. To calculate this loss, the stress test uses a statistical model of the historical relationship between actual loss of principal balance on loans that have defaulted and the loss of principal balance predicted solely by calculating amortization on the loan and updating the property values with the HPI. Sale proceeds are then calculated as UPB minus the estimated loss of principal balance. Proceeds vary with differences in house-price appreciation and loan terms.

(ii) Transaction Costs

The stress test includes two transaction cost elements in loss severity calculations: foreclosure/legal expenses, and property holding and disposition costs.[127] Property holding and disposition costs are combined in the proposed stress test because they are both expensed at the time of property disposition. OFHEO proposes to use averages of these cost elements—in percent of outstanding principal balance—from all Enterprise experience with foreclosure and REO properties.

OFHEO did not follow Freddie Mac's recommendation to use all cost elements directly from the benchmark loss experience for transaction costs, because the stress test is national in scope. Therefore, it is appropriate to have a national blend of institutional factors such as foreclosure costs, property management fees, and sales

[127] Legal expenses are dominated by foreclosure costs, but they also include costs associated with gaining releases from borrower bankruptcy stays and property evictions.

expenses, rather than the four-State blend from the benchmark experience.

(iii) Funding Costs

Funding costs are considered an element of loss severity because the Enterprises must fund non-earning assets: first the defaulted loans, and then the REO properties. In its ANPR comments, Freddie Mac suggested that funding costs should be measured at the mortgage interest rate for the period from date of default to foreclosure completion. OFHEO agrees that the stress test should model funding costs. However, Freddie Mac's recommended approach ignores funding costs during the REO time period and would provide inaccurate measures of funding costs during the delinquency/default period. In the down-rate scenario of the stress test, using the mortgage coupon rate for funding costs would overstate funding costs, while in the up-rate scenario it would understate funding costs.

With one exception, the stress test measures asset funding costs through present-value discounting techniques, rather than computing explicit interest charges. Therefore, all severity elements are discounted by a cost-of-funds rate to produce the present value of each element in the month of default, regardless of when it may occur after that date. Cash flow discounting provides a consistent method of accounting for all timing issues involving cash flows from mortgage default to property disposition.

The one exception to the rule of calculating funding costs through present-value discounting techniques is the explicit cost of covering interest passed through to investors in securitized loans (mortgage-backed securities). These passthroughs occur for the first four months of loan delinquency, during which time the stress test uses the passthrough rate (the interest rate paid to holders of the securities) to calculate the asset funding cost. After the fourth month, when the loans have been repurchased from security pools and placed in Enterprise retained portfolios, the stress test treats these defaults identically to defaults in retained portfolios.

(iv) Factors Not Modeled

ANPR commenters suggested several explanatory factors that are not included in the proposed single family loss severity model. These include distinctions based on State foreclosure laws, household liquidity, and the presence of private mortgage insurance.[128]

(a) State Foreclosure Law Differences

Freddie Mac suggested that OFHEO not make State-level distinctions in loss severity calculations, explaining that attributing ''differences in loss rates by states would approach undue intrusion and inappropriate micromanagement of the Enterprises.'' In contrast, NAR recommended that OFHEO make State distinctions.

Although foreclosure time-frames and costs may vary based on State law and practice, OFHEO agrees with Freddie Mac that it would be inappropriate to model State-level differences. First, these differences do not represent loan characteristics, and, therefore, under OFHEO's approach to selecting variables to apply in the stress test, they are not appropriate. Second, if OFHEO were to allow for State-level differences in credit costs, the stress test would, essentially, be establishing State-specific capital requirements based upon nuances of State law. OFHEO would need to monitor developments in the many different State laws over time to adjust the parameters of the stress test. Third, the fact that the stress test uses loan data aggregated at the Census division level means that much of the variability in foreclosure costs observed at the State level disappears.

(b) Independence of Loss Severity Rates From Default Rates

Freddie Mac commented that default and loss severity are products of the same underlying factors, most particularly original LTV and property value appreciation over the life of the mortgage. NAR recommended that the loss severity model ''only include those factors that are independent of the incidence of default.'' OFHEO agrees with Freddie Mac on this point, because OFHEO's research indicates that loan seasoning has an important impact upon severity rates that is independent of its impact on defaults. The use of loan seasoning in the stress test reflects differences in loss severity across loans. This approach is also consistent with NAR's comment, because estimating the impact of seasoning on loss severity independently from its impact on defaults avoids duplicating seasoning's effect on credit losses.

(c) Household Liquidity

NAR stated that liquidity of the household under stress is an important factor in the loss severity equation. OFHEO notes that for the single family loss severity analysis, the stress test considers housing-related liquidity of a household through loan seasoning. That is, updating the LTV provides some indication of the ability of borrowers to sell or borrow against their properties in order to provide liquidity. However, the stress test does not account directly for non-housing wealth or liquidity of borrowers. It is unclear how these factors could be measured or estimated accurately.

(d) Private Mortgage Insurance

NAR also commented that the presence of private mortgage insurance is a variable that can influence the time to foreclosure and therefore, presumably, holding costs. OFHEO, however, has found insufficient evidence that the presence of mortgage insurance has any meaningful impact on foreclosure time. Both Enterprises submit their own foreclosure time guidelines to seller/servicers, which are independent of the presence of mortgage insurance. Accordingly, the presence of private mortgage insurance is not included as a variable in the loss severity equations.

This issue is distinct from the question of how OFHEO should account for private mortgage insurance proceeds in the loss severity calculations. Several commenters noted that the loss severity calculation should deduct mortgage insurance proceeds from losses on loans covered by such insurance. OFHEO agrees that the loss severity calculation should account for mortgage insurance proceeds. This issue is discussed extensively in section III.C., Mortgage Credit Enhancements.

c. REO House Price Index

In the ANPR, OFHEO asked what price index would be appropriate for REO properties. The question arose because defaulted loans generally have lower house-price appreciation rates than the market average, which is captured by HPI growth over time. After considering the ANPR comments and OFHEO's own research, OFHEO proposes an equation to relate actual declines in value for REO properties to changes in the HPI. This approach, which is described in section 3.5.3.3.3.1, Calculate Proceeds from Property Sale, of the Regulation Appendix, provides the information needed to predict accurately the loss of loan principal balance in loss severity calculations, but avoids the added complexity of creating a separate index.

All five commenters that addressed this issue recognized that, without

[128] Although private mortgage insurance is not an explanatory variable, proceeds from such insurance are accounted for in the severity calculation.

adjustment, the HPI would not provide an adequate measure of REO price changes. However, none recommended creation of a separate REO index. Four commenters (MRAC, ACB, VA, and Freddie Mac) recommended modifying the general price index. MRAC suggested that a general HPI be used in conjunction with analysis of variances of prices to determine whether foreclosure prices have experienced slower appreciation or greater depreciation than the market average. ACB suggested that, rather than developing an REO price index, OFHEO study the ''left tail'' of the distribution of house prices in general. The term ''left tail'' refers to those houses with the smallest appreciation rates. S&P provided to OFHEO the rates of property value loss for foreclosures during the Great Depression.

The proposed approach incorporates a statistical model based upon an analysis like that suggested by MRAC and ACB. The model predicts how far into the left tail each REO property value can be expected to be, relative to the outstanding mortgage balance, throughout the stress period. OFHEO's proposed approach essentially follows the specific recommendations of MRAC and ACB for modification of the HPI.

The VA suggested using a general house price index, re-weighted to capture the regional distribution of REO properties. OFHEO agrees that regional differences in REO appreciation rates should be captured. The proposed regulation therefore incorporates Census division differences in historical HPI values and historical measures of the dispersion of house values around levels suggested by the HPI. *See* section III.A.4.d., Property Valuation.

NAR did not recommend a specific approach, but cautioned that an REO price index might not be meaningful for Enterprise loans, because the Enterprises tend to sell REO properties quickly, thus limiting exposure to undue loss of value. For that reason, NAR recommended that any analysis of REO property values be based solely on Enterprise data. OFHEO also concurs with NAR that an REO price index built on non-Enterprise data might be of limited usefulness for Enterprise loans. Given the richness and volume of the Enterprise data, and consistent with all other parts of the stress test, OFHEO has based the model of REO property values on Enterprise data. However, rather than developing a separate price index for REO properties, the proposed stress test models REO property value as a function of the path of the HPI. In addition, OFHEO proposes to adjust the resulting rate of loss of principal balance rate to reflect the fact that REO property values in the benchmark loss experience were lower in relation to the HPI than the REO property values in other Enterprise experience.

d. Multifamily Loss Severity

With respect to loss severity, the stress test uses the same cost elements for multifamily loans as for single family loans. However, there is no loan seasoning, nor is statistical analysis used to determine loss of loan principal balance. All cost and revenue elements of multifamily loss severity rates are averages from Enterprise experience.

7. Relating Losses to the Benchmark Loss Experience

The 1992 Act specifies that the stress test should apply rates of default and loss severity that are ''reasonably related'' to the highest rates experienced by the Enterprises for a period of at least two years in any contiguous areas having at least five percent of the nation's population (the benchmark loss experience).[129] The stress test satisfies this reasonable relationship requirement in the context of two severe interest rate environments that are quite different from the interest rate environment of the benchmark loss experience. At the same time, the stress test also accounts for appropriate distinctions in credit risk across loan types and characteristics. OFHEO believes that the multivariate mortgage performance models developed by OFHEO are the best means of specifying loss rates for the wide variety of loans held by the Enterprises under the different interest rate scenarios specified in the statute. However, for reasons explained below, the models are adjusted to produce loss rates that are reasonably related to the losses experienced on the 30-year fixed-rate, single family mortgages in the benchmark time and place.

Both Fannie Mae and Freddie Mac provided comments on how to implement a statistical model of mortgage performance that would be reasonably related to the benchmark loss experience. As discussed earlier, neither Fannie Mae nor Freddie Mac recommended a joint, multivariate statistical model of conditional default and prepayment rates. However, both discussed how other models could be used in the stress test and commented that a reasonable relation to the benchmark loss experience could be achieved by estimating those models solely on data from the benchmark loss experience.[130] They noted that the advantage of limiting the statistical sample in that way is to allow the resulting equations to capture benchmark economic conditions without having explicit explanatory variables for economic conditions in the stress test.

The suggestion from Fannie Mae and Freddie Mac that the mortgage performance models be estimated solely with data from the benchmark loss experience, although appealing conceptually, turned out to be impractical. The benchmark loans comprise too small and homogeneous a set of loans to estimate models for all the Enterprises' current loans. Using a much larger sample of historical loan performance experience was important when estimating the statistical models, because it provided a wide variety of economic circumstances and mortgage experience upon which to base estimation of the model parameters. Like current Enterprise loan portfolios, the samples used to estimate the statistical equations include mortgages originated over many years and geographic locations, and having distributions across other factors of mortgage performance—such as age, coupon type or amortization terms—that differ from those of the benchmark loans.

The ''reasonable relationship'' requirement of the 1992 Act means that the adverse credit stress of the benchmark loss experience should be reflected in the stress test mortgage losses. However, when the mortgage performance models are applied unadjusted to a pool of loans with the same characteristics as the benchmark loans, using interest rate and house-price appreciation paths equivalent to those of the benchmark time and place, the resulting default and severity rates are slightly lower than the actual rates for the benchmark loss experience. This result should be expected, because the mortgage performance models are estimated from data on a broad range of historical experience, rather than just data from the benchmark loss experience. The benchmark loss experience was from the time and place with the worst mortgage losses for the Enterprises. Therefore it is reasonable to expect it to have default and severity rates somewhat higher than would be predicted based solely upon the explanatory variables used in the stress test. For this reason, the stress test

[129] 1992 Act, section 1361(a)(1) (12 U.S.C. 4611(a)(1)).

[130] Fannie Mae recommended estimation of a statistical model of total terminations and Freddie Mac recommended estimation of a statistical model of prepayments only.

includes adjustments to the models to reflect more fully the additional stress of the benchmark experience.

OFHEO proposes to relate losses projected by the statistical equations to the benchmark loss experience in two ways. First, benchmark house-price growth rates and multifamily (rental) market economic conditions that coincide with the time and place of the benchmark loss experience are applied to loans in the starting portfolio during the stress test period. Second, the default and severity rates predicted by statistical equations are increased, or ''calibrated,'' to the benchmark loss experience rates, so that if newly originated loans with similar characteristics to those comprising the benchmark sample were subjected to the same economic circumstances as occurred in the benchmark loss experience, the statistical model of mortgage performance would project ten-year cumulative default and average severity rates equal to the rates actually observed for the benchmark sample.[131] Under this approach, default and loss severity rates differ from the benchmark rates only to the extent interest rates, property values, and loan characteristics are different from the benchmark sample, or to the extent adjustments are necessary to account for other statutory requirements.[132] Because of the addition of this benchmark ''calibration'' factor to default and loss severity equations, loss rates for all loans are slightly higher than would otherwise be projected.

Although the principles for reasonably relating stress test losses to the benchmark loss experience are the same for single family and multifamily loans, the methods of reasonably relating losses to the benchmark differ and are discussed separately below.

a. Single Family Calibration

For single family loans, calibration constants are added to default and loss severity rates.[133] These constants are set forth in sections 3.5.2.3.2.9 and 3.5.3.3.3 of the Regulation Appendix. Their development is described in section IV.B.8., Consistency with the Historical Benchmark Experience, of the Technical Supplement.

The calibration constants were computed in three steps. First, all benchmark loans were assigned the same historical house-price experience—the ten-year sequence of appreciation rates from the OFHEO HPI for the West South Central Census Division, commencing in 1984, first quarter.[134] Second, using the statistical equations estimated on a broader historical loan sample, OFHEO projected the ten-year experience of loans comprising the benchmark sample, computing the ten-year cumulative default rate and ten-year average loss severity rate. These rates were measured in the same manner for the benchmark in NPR1.[135] Third, these cumulative rates were compared to the actual cumulative default and prepayment rates computed for the benchmark in NPR1, and adjustment constants were calculated that, when applied in the models, would yield the equivalent default and loss severity rates.

The adjustment constant for loss severity rates is not applied to the entire loss severity rate, but rather to the loss of loan principal balance element of the loss severity rate. The constant is computed by subtracting the loss of loan principal balance that was predicted by the single family loss severity model from the loss of loan principal balance that occurred on defaulted loans in the benchmark loss experience. The second element of severity cost, transaction costs, was not adjusted to reflect benchmark conditions. OFHEO found it more appropriate in a national stress test to use a national blend of the institutional factors such as foreclosure costs, property management fees, and property sales expenses that comprise this element. The third element of loss severity cost, asset funding costs, enters the stress test as an imputed interest cost. As described in more detail in section 3.5.3 of the Regulation Appendix, this element is related to the benchmark loss experience through the use of foreclosure and property disposition event timing from the benchmark loss experience. The timing of these events determines the periods over which funding costs are calculated.

b. Relating Other Single Family Products to the Benchmark

In the ANPR, OFHEO asked how to relate other types of mortgages to the benchmark, which was developed based on single family, 30-year, fixed-rate mortgages. The commenters' consensus was that some type of multiplier approach to alternative single family mortgages should be used, except for ARMs. These comments are discussed below.

(i) ANPR Comments

NAR suggested that OFHEO develop statistical models of default for fixed- and adjustable-rate mortgages and relate the performance of other mortgage types to them. NAR also pointed out, however, that this type of relationship might be difficult to establish for new mortgage types for which there is insufficient historical experience. NAR suggested applying the benchmark default experience to these loans rather than measuring the difference in risk from the benchmark experience. VA addressed the same concern, suggesting that multipliers should be based on historical periods in which the other mortgage types had significant shares of the market. Specifically, VA suggested that measures of performance from those periods of other single family mortgage types relative to the 30-year, fixed-rate product could be used to impute the necessary performance differences from the benchmark loss experience to use in the stress test. Freddie Mac stated that any default-rate multipliers should be based on a broader range of Enterprise historical experience than the benchmark time and place.

Freddie Mac, although recommending that OFHEO use simple multipliers, also raised a concern that loans receiving multiple multiplier factors could end up with unreasonably high stress test default rates. It cited, as an example, a balloon loan on an investor-owned condominium. If the stress test were to apply default-rate multipliers for each of these three mortgage type categories

[131] Loans comprising the benchmark sample were 30-year fixed-rate loans.

[132] Differences in interest rates, property values, and loan characteristics can have very significant effects, however. The average mortgage credit loss rate for the two Enterprises in the benchmark sample was 9.4 percent. In the up-rate scenario of the stress test for June 1997, the average loss rate was 1.8 percent, while in the down-rate scenario it was 1.4 percent. The loss rate for the benchmark sample does not take account of mortgage insurance and other credit enhancements. Losses on benchmark loans after accounting for these receipts would have been seven percent.

[133] The calibration constant used in the single family default rate equations is in addition to the particular product-type multiplier factors discussed earlier. The product-type multipliers relate other products to the benchmark 30-year fixed-rate loans, while the calibration constant relates all loans to the severe benchmark loss experience.

[134] The West South Central Census Division does not exactly match the four-State benchmark region, but its use here to represent benchmark economics is consistent with OFHEO's proposal to aggregate data based on Census divisions and to apply historical Census division-level house price growth rates to season loans at the beginning of the stress test. What is most important is that the price series used to calibrate the statistical equations is the same series that will be used in the stress test itself. The actual ten-year house-price experience of the West South Central Division and the four-State benchmark area, 1984–1993, are very similar.

[135] The ten-year cumulative default rate was computed as the sum of original UPBs for defaulted loans, divided by the sum of original UPBs for all loans in the sample. The average severity rate was calculated in similar fashion. Following the method used to identify the benchmark experience, the calibration procedure computes ten-year default and severity rates for each Enterprise separately, and then the two Enterprise-specific rates are averaged.

(condominium, investor-owned, and balloon), the combined risk factor premium could be unreasonably high. To remedy this problem, Freddie Mac recommended that the stress test incorporate limits on the interaction of risk factors.

MRAC suggested that, if sufficient data were available, OFHEO might either create historical tables of default rates by various loan characteristics, in order to establish product-type multipliers, or use some type of regression analysis to discern performance differences among mortgage types. The MBA suggested that multipliers are the best approach because they are currently used by the Enterprises and therefore would provide a simple way for them to implement the risk-based capital standards.

OTS cautioned that multipliers might not be appropriate for ARMs or for multifamily loans, because the credit loss experience of these loans may not correlate well with that of fixed-rate, single family loans. OTS recommended that OFHEO consider using separate benchmarks for different types of loans. ACB, however, commented that there is no statutory requirement to incorporate the worst experience for each mortgage type into the stress test, and that a multiplier analysis for single family loan types would be sufficient.

Consistent with its recommendation that OFHEO not develop a statistical model of conditional default rates, Fannie Mae suggested that multipliers be applied to (cumulative) loss rates, rather than to conditional default rates.

(ii) OFHEO's Response

The stress test approach of adding product type adjustment factors as explanatory variables in a single family default equation is consistent with the multiplier approach recommended by commenters. However, the stress test approach does not have the shortcomings about which some commenters cautioned. It relies upon a broader historical experience than the benchmark sample alone to gauge the relative risk of other mortgage types, and it controls for the multiple multipliers problem outlined by Freddie Mac. The multiple multipliers problem is avoided because product type adjustment factors are estimated as part of the statistical default equation. The equation computes the marginal impact of each product type after controlling for all other explanatory variables. Using simple multipliers with limits on the amount of adjustment, as recommended by Freddie Mac, would either be too imprecise to reflect the relative risk of the loans that fall into multiple product type categories, or else would become as complex as a statistical model in order to account for all of the conceivable combinations of product types.

OFHEO agrees with the OTS comment that a multiplier approach is not appropriate for ARMs. Equations for single family default and prepayment rates in the stress test are, therefore, estimated separately for ARMs. This is appropriate because the adjustable payment features of these loans create unique incentives to either default or prepay that are not found in other mortgage types. The ARM default equation does, however, receive the same benchmark calibration constant used in the other two single family default equations. The use of this constant reasonably relates ARMs to the added stress of the benchmark loss experience in a manner consistent with how other single family product types are related to the benchmark loss experience.

c. Relating Multifamily Mortgage Performance to the Benchmark

In the ANPR, OFHEO requested comment on how the stress test multifamily mortgage performance should be related to the single family benchmark. Respondents to the ANPR mentioned the need to capture the different underwriting variables and economic factors that would influence multifamily performance directly. They warned against applying multipliers to single family losses to generate multifamily losses. These concerns were raised by OTS, MBA, Fannie Mae, and Freddie Mac. In addition, OTS and Fannie Mae suggested that OFHEO may need to explore options other than relating stress test credit losses on multifamily loans to the single family benchmark.

OFHEO agrees with the commenters' concerns about using a simple multiplier approach for multifamily loans, and proposes instead a separate statistical model of multifamily mortgage performance based on multifamily market conditions, property financial characteristics (DCR and LTV), and loan terms—whether fully amortizing or balloon, or having fixed or adjustable interest rates. The statistical model allows the application of OFHEO's first principle, outlined above in section III. A. 5. e., Choice of Explanatory Variables for Default and Prepayment, for relating stress test losses to the benchmark: using economic conditions of the benchmark experience in the stress test. OFHEO believes that multifamily rent and vacancy indexes from the benchmark time and place provide the best means to relate starting multifamily loan portfolios to the benchmark loss experience. These indexes account for the economic decline that occurred in the benchmark region in the economic factors that affect multifamily mortgage credit risk. Therefore, the stress test creates a reasonable relationship to the benchmark loss experience by using vacancy rates from and percent changes in rents from the benchmark loss experience to update property financials (DCR and LTV) throughout the stress period.

Because of the small number (13) of multifamily loans purchased by the Enterprises in the benchmark region during 1983 and 1984, it is not possible to compute calibration adjustments like those in the single family default and severity equations. Instead, OFHEO proposes to treat all defaults as full foreclosure events and apply loss severity rates without consideration of loan seasoning. The effect of this approach is to create higher credit losses than if the stress test were to account for multifamily defaults that are resolved without foreclosure and adjust severity rates to account for the age of loans.

Methodologically, treating all multifamily defaults as foreclosure events is consistent with OFHEO's proposed approach to single family credit loss generation in the stress test. However, OFHEO is aware that use of various default resolution strategies other than foreclosure (loss mitigation) played an important role in controlling multifamily default losses in the severe environment of the late 1980s and early 1990s. Therefore, accounting for loss mitigation in the stress test would tend to decrease losses for any given economic conditions. Treating all defaults as foreclosures for calibration purposes, rather than allowing for loss mitigation efforts, results in an increase in loss severity—before application of any credit enhancements—of 6.5 percent per defaulting loan.[136]

There is an exception to the rule of treating all defaults as foreclosure events for Enterprise loan programs that require the seller/servicer to repurchase loans that become 90-days delinquent. For loans in these programs, the recorded ''default'' event at the Enterprises is the point at which a loan becomes 90 days delinquent, rather than a foreclosure-like event where the Enterprise obtains title to the collateral property.

[136] The 6.5 percent figure is arrived at by multiplying the 13 percent of defaults resolved with alternatives to foreclosure by a 50 percent loss rate reduction factor.

The stress test loss severity rate for these loans is 39 percent.[137] The 39 percent loss severity rate reflects experience of the Enterprises during the stressful conditions of the early 1990s, including approximately 50 percent cures (or modifications) and 50 percent foreclosures on 90-day delinquencies. OFHEO research indicates that this is a reasonable approximation for the stress test.

8. Inflation Adjustment

The 1992 Act specifies that, to the extent that the ten-year CMT increases by more than 50 percent over its average for the nine months preceding the starting date of the stress test, credit losses must be adjusted ''to reflect a correspondingly higher rate of general price inflation.'' [138] In the stress test, mortgage credit losses are not related to rates of general price inflation, but most are related to rates of house price inflation.[139] Implementing this provision of the statute requires consideration of the relationship between interest rates, general inflation rates, and house price inflation rates.

These relationships are complex. Over recent decades, changes in broad inflation measures generally have preceded changes in interest rates in the same direction. And changes in interest rates have been accompanied by changes in house price inflation rates in the opposite direction. Thus, over short and intermediate periods of time, interest rates and house price inflation rates have often moved divergently. For example, consider the three five-year periods beginning in 1975. From the beginning of 1975 to the end of 1979, the ten-year CMT averaged about 8 percent, while house prices rose at an 11 percent annual rate. In the following five-year period, from 1980 to 1984, interest rates were 50 percent higher (12 percent), while house price inflation fell to 4 percent. Then in the third five-year period, 1985 to 1989, interest rates declined to 9 percent, while house price gains accelerated to 7 percent.[140] Over longer periods of time, however, these changes have tended to reverse themselves. For periods of ten years or more, higher (lower) than average interest rate levels have generally been associated with higher (lower) than average rates of general inflation and house price inflation.

In unusual environments, such as those represented by the economic conditions of the stress test, average past relationships between interest rates, general inflation rates, and house price inflation rates may not prevail. The nature or cause of the projected mortgage credit stresses in the stress test are not specified in the statute. They could involve problems particular to housing markets, such that house price behavior deviates persistently from general inflation patterns. Or they could be focused on non-house-price factors, such as unemployment, relocation, or divorce rates.

Except to the extent that the ten-year CMT rises in the up-rate scenario by more than 50 percent, the stress test does not project any differences in house price changes or other sources of credit stress in the two interest rate scenarios. And, aside from the inflation adjustment, the specific pattern of house price changes used in both scenarios is not designed to be consistent with any particular pattern of interest rates. It was chosen to replicate (and encapsulate in one variable) the overall level of credit stress in the benchmark loss experience.

In order to implement the statutory requirement, the stress test projects that cumulative increases in house prices, a component of general inflation, are higher in the up-rate scenario by an amount that reflects, percentage point for percentage point, any positive difference between the ten-year CMT and the level corresponding to a 50 percent increase. Thus, for example, if the ten-year CMT starts at 6 percent and increases by 75 percent to 10.5 percent, the increase in excess of 50 percent is 1.5 percentage points. The cumulative change in house prices during the up-rate scenario would equal the cumulative change during the down-rate scenario plus an upward adjustment. The adjustment is the amount needed to reflect what the cumulative increase would be if the house price inflation rate were 1.5 percent higher, on average, throughout the part of the stress period in which the ten-year CMT exceeds 9 percent.[141]

In recognition of the likely short- and intermediate-term divergence between interest rates and house price behavior, the stress test concentrates all of the adjustment in the final five years of the stress period. Thus, house prices are identical in the two stress test interest rate scenarios during the first five years, but increase much more rapidly in the last five years of the up-rate scenario than they do in the down-rate scenario.

Several respondents to OFHEO's ANPR commented on this issue. VA opposed any adjustment, arguing that while the long-term behavior of house price inflation and general inflation is consistent, the short-term relationship is weak, and the relationship between interest rates and house prices ''is even more tenuous.'' VA further agrees that specific economic conditions can disrupt any general relationships, and that an adjustment would be inconsistent with the approach of private rating agencies. OFHEO believes, however, that some adjustment is required by the statutory language.

HUD argued that adjusting the rate of increase in house prices throughout the stress period on a one-to-one basis with general price inflation would deny the role of changes in real interest rates over time. HUD suggested that OFHEO consider current trends and long-run relationships between real interest rates and house prices. NAR suggested that a one-to-one relationship is appropriate for long-term assumptions, and ACB commented similarly. OFHEO believes that its approach, which uses a one-to-one relationship for the cumulative change but concentrates the change in the last five years of the stress period, is not inconsistent with any of these recommendations.

Freddie Mac recommended that house price inflation should vary with interest rates in a one-to-one relationship, not only with respect to increases in the ten-year CMT exceeding 50 percent, but also with respect to all interest rate changes. House price inflation rates would be based on rates current at the start of the stress period and rise or fall by amounts equal to the change in the ten-year CMT in both scenarios. Such an approach could result in more severe credit losses in the down-rate scenario and very few credit losses in the up-rate scenario. OFHEO believes that the stress test should reflect the possibility that substantial credit losses would occur in either scenario. The recommended

[137] This rate is discounted by 12 months to reflect the average time from the default date (30 days after last paid installment date) to final resolution.

[138] 1992 Act, section 1361(a)(2)(E) (12 U.S.C. 4611(a)(2)(E)).

[139] Multifamily credit losses are related to rent growth rates. The same adjustment described here for house price inflation rates is also made to rent inflation rates.

[140] General inflation rates (based on the CPI) followed a still different pattern. They averaged 8 percent per year during the first five-year period, 7 percent in the second, and 3 percent in the third five-year period.

[141] The stress test would calculate the cumulative adjustment factor in this case to be $1.015^{9\frac{1}{6}}$, so final house price levels in the up-rate scenario would be 14.6 percent higher than they would be in the down-rate scenario. In this formula, 9⅙ represents the number of years the ten-year CMT exceeds 9 percent by the full 1.5 percentage points plus two months to reflect the period in which the ten-year CMT exceeds 9 percent by a smaller amount. If the ten-year CMT increases 75 percent over the base month, a 50 percent increase will be achieved by month eight. The full increase will be achieved by month 12. For the purposes of this calculation, the result is the same as it would be if the extra 25 percent lasted for nine years and two months.

approach also would not have any obvious relationship to the benchmark loss experience. Applying the approach at the time the benchmark loans were originated would result in much stronger house price growth than actually occurred in the benchmark area.

Freddie Mac further argued that a stress test that incorporated a ten-year CMT that exceeded the rate of house price appreciation by more than 6.5 percentage points over a ten-year period would be inconsistent with national historical experience and, therefore, inappropriate. However, national historical experience is not an appropriate criterion for the stress test's key source of mortgage credit stress. Credit losses in the stress test are required to exceed national historical experience. They are based on the worst regional, not national, experience.[142] More importantly, as discussed above, house price projections in the stress test are not designed to correspond to any particular interest rate level. Rather, they are simply a means of incorporating an overall credit stress level that is comparable to the benchmark loss experience and which may reflect stresses from a variety of non-house price sources not explicitly included in the mortgage performance model.

B. Interest Rates

The 1992 Act specifies the level of the constant maturity Treasury yield (CMT) for ten-year securities during the last nine years of the stress period.[143] However, only general guidance is provided for the levels of yields on Treasury securities with different maturities. Also, yields on other financial instruments are not explicitly mentioned. The behavior of yields on financial instruments other than ten-year Treasury securities will have potentially substantial and pervasive effects on the Enterprises during the stress period. Those yields will determine the cost of new debt issued and earnings on new investments, as well as the interest rates paid or earned on assets, liabilities, or derivatives contracts that are tied to market yield indexes. They will also have a significant effect on the volumes of mortgage prepayments and defaults. The magnitude of the effects on an Enterprise during the stress period will depend greatly on the Enterprise's funding strategies at the start of the stress period.

1. Yields on Treasury Securities

a. Statutory Requirements

The 1992 Act describes two interest rate scenarios (one rising and one falling) based on movements in the ten-year CMT. In the rising or up-rate scenario, the ten-year CMT increases during the first year of the stress test period and then remains constant at the greater of: (1) 600 basis points above the average yield during the preceding nine months; or (2) 160 percent of the average yield during the preceding three years. However, in no case may the yield increase to more than 175 percent of the average yield over the preceding nine months. In the falling or down-rate scenario, the ten-year CMT decreases during the first year of the stress period and then remains constant at the lesser of: (1) 600 basis points below the average yield during the preceding nine months; or (2) 60 percent of the average yield during the preceding three years. However, in no case may the yield decrease to less than 50 percent of the average yield over the preceding nine months.

The 1992 Act does not specify the shape of the yield curve during the stress period. Rather, it simply requires that the levels of other Treasury yields ''change relative to the 10-year Constant Maturity Treasury (CMT) yield in patterns and for durations that are reasonably related to historical experience and are judged reasonable by the Director.'' [144] The statute also does not specify the manner in which the ten-year CMT moves during the first year of the stress period to reach the level required for the remainder of the period.

In its comments to OFHEO's ANPR, ACB suggested that OFHEO consider using stochastic projections of all interest rates, if OFHEO determined that stochastic projections were consistent with statutory requirements. ACB noted that the process could be constrained to insure that the ten-year CMT reached its required level during the final nine years of the stress period on an average basis. OFHEO has determined that such an approach would not be compatible with the 1992 Act. That statute clearly specifies that the ten-year CMT will be constant during the final nine years of the stress period. Furthermore, as Fannie Mae commented, using a stochastic model for determining interest rates would create unnecessary uncertainty about what amount of capital would actually be required for a given set of risk positions. A stochastic model also would add unnecessary complexity to the regulation. Accordingly, OFHEO proposes that all interest rates during the stress period be fully determined by past data on interest rates.

b. Yields of Other Treasury Maturities During the Final Nine Years

(i) Constant or Varying Yields

OFHEO considered whether the Treasury yield curve should be constant over the final nine years of the stress period or whether it should change in some specific manner. OFHEO proposes to use a constant yield curve. While yields are extremely unlikely to remain constant or even roughly so over a period as long as nine years, there are no serious disadvantages to using such an approach in the stress test, and there are compelling advantages.

A constant yield curve is a straightforward approach that is consistent with the statutory specification of a constant ten-year CMT. The purpose of the interest rate component of the stress test is to assess an Enterprise's ability to withstand a prolonged shift to a much higher or much lower interest rate environment. No specific pattern of yield changes can fully capture the range of possible future adverse changes. Based on historical experience, one would expect all interest rates to fluctuate over a broad range during a period as long as nine years. Different underlying macroeconomic circumstances would be associated with different evolutions of the entire yield curve, including the ten-year CMT. Tying the stress test to one specific set of macroeconomic circumstances would tend to limit its general usefulness. The real-life danger the Enterprises face of much higher or much lower interest rates during the next decade is not focused on any particular portion of that ten-year period. Designing a stress test with any specific pattern of interest rate changes after the first year of the stress period would imply a belief that Enterprise risk exposures in some future years would be a matter of greater public concern than in other years. While an argument could be made that near-term risk exposures would create losses with a higher present value, that concern should be balanced by a recognition that the risk of a very different interest rate environment is greater for distant years than for the near-term.

A stress test with interest rates that are especially high or low in particular

[142] The average ten-year CMT exceeded average house price growth in the West South Central Division during the 1980s by 9.5 percentage points. For the benchmark loss experience, the difference was 8.5 percentage points.

[143] 1992 Act, section 1361(a)(2) (12 U.S.C 4611(a)(2)).

[144] 1992 Act, section 1361(a)(2)(D) (12 U.S.C. 4611(a)(2)(D)).

future years would encourage Enterprise hedging strategies to focus on those specific years. Risks in other years, when stress test projections were more moderate, might receive relative neglect. The Enterprise would thus be providing more protection against more adverse, but less likely, interest rates in some years at the expense of less protection against less adverse, but more likely, interest rates in other years. Such an incentive would provide less general protection and thereby increase the risk of failure.

In their ANPR comments, Fannie Mae and VA suggested specific fixed yield curves, consistent with OFHEO's proposal in this regard. Freddie Mac recommended a considerably more complex approach that would generally result in relatively more adverse short-term interest rates in the early part of the final nine years of the stress period and less adverse short-term interest rates later. OFHEO believes its proposal is much simpler and will provide better general protection against Enterprise failure for the reasons discussed above.

Freddie Mac argued that a fixed yield curve would be unreasonable for two reasons. First, Freddie Mac stated that a fixed curve would be inconsistent with the statutory requirements that changes in yields on Treasury securities with maturities other than ten-years ''will change relative to the 10-year constant maturity Treasury yield in patterns and for durations that are reasonably related to historical experience.'' It is clear from the legislative history that Congress did not intend to prohibit constant yield curves, per se, but rather wanted to prohibit unusual yield curves lasting for a longer time than could be reasonably related to historical experience. The language of the statute follows the original Senate-passed bill, except that ''reasonably related to'' in the quoted phrase was substituted for ''within the range of,'' and a specific restriction on unusual yield curves was removed. The Senate Committee, in explaining its understanding of the yield curve provision, actually recommended that the yield curve be fixed during at least the final five years of the stress period.[145]

Second, Freddie Mac argued that a constant yield curve ''would be of little value in measuring the ability of an Enterprise to absorb losses in relation to its risks'' because interest rate volatility would disappear and the prices of options would approach zero. Market estimates of interest rate volatility, however, play no important role in the stress test OFHEO is proposing. The Enterprises are not projected to buy or sell any options, as this is a ''no new business'' stress test. While option value does affect decisions about option exercise, and those decisions are an important element of the stress test, the interest rate movements in the stress test are quite large. In such circumstances, Enterprise decisions about option exercise will generally be relatively insensitive to precise measures of option value. Homeowners' decisions to exercise their options to prepay their mortgages are also based on past homeowner responses to large changes in interest rates and not on specific measures of volatility. Stress test projections relating to the exercise of options implicitly assume that expectations about volatility are within normal ranges, despite the lack of change in interest rates. The proposed approach is an efficient simplification that does not distort Enterprise risks in any meaningful way.

[145] S. Rep. No. 102–282, at 22 (1992).

(ii) Choice of Fixed Yield Curve Shapes

OFHEO proposes that all Treasury yields for key maturities (three-and six-month; one-, three-, five-, and 20-year) in the final nine years of the up-rate scenario be equal to the ten-year CMT. In the final nine years of the down-rate scenario, OFHEO proposes that all key Treasury yields have the same ratio to the ten-year CMT that they had, on average, during the nine-year period from May 1986 through April 1995. The proposed yield curves for both interest rate scenarios correspond to historical experience.

OFHEO based its selection of yield curves on an examination of historical data on Treasury yields. Data are available starting in December 1958. OFHEO focused on the relationship between a short-term (six-month) yield and the ten-year yield.[146] From 1959 through 1996, the average yield curve slope, measured by the ratio of the six-month CMT to the ten-year CMT, was 0.88, a moderate upward slope. However, when calculated on a monthly basis, this slope has varied considerably through time (*See* Table 26, Frequency Distribution of Yield Curve Slopes, 1959—1996). Monthly slopes have been as low as 0.48 (September and October 1992) and as high as 1.29 (March 1980). In more than half of the months, yield curves were roughly flat or downward sloping (slopes above 0.95) or were steeply upward sloping (slopes below 0.75).

[146] In the following discussion, yields of six-month Treasury bills are expressed on a bond-equivalent basis. The six-month maturity has the advantage that the timing of its payments are consistent with the interest rate payment cycle of Treasury notes and bonds, ensuring comparability of yields across maturities.

Table 26. Frequency Distribution of Yield Curve Slopes, 1959 - 1996

Ratio of 6-Month CMT to Ten-Year CMT	Number of Months
1.25 - 1.35	2
1.15 - 1.25	21
1.05 - 1.15	41
0.95 - 1.05	77
0.85 - 0.95	89
0.75 - 0.85	111
0.65 - 0.75	80
0.55 - 0.65	21
0.45 - 0.55	14

Of particular relevance are the average slopes over periods of 108 months (nine years) and their relationship to previous increases or decreases in yields. Ratios of the average six-month Treasury CMT to the average ten-year CMT for periods of 108 months ranged from 0.77 (for periods ending from January 1994 through April 1996) to 0.99 (for periods ending from September 1981 through June 1982). OFHEO must project yields curves for a nine-year period in which the ten-year CMT has increased by 75 percent, and decreased by 50 percent, from its average in the nine months ending one year before the beginning of the nine-year period.[147] Accordingly, OFHEO sought to determine whether historical data suggest any relationship between changes in average ten-year CMT and yield curve slopes for relevant time periods.

At no time during the past 40 years have ten-year CMTs changed as greatly as required in the stress test. The largest comparable increase was 56.3 percent from the nine-month average of 6.04 percent during November 1971 to July 1972 to the nine-year average of 9.44 percent during August 1973 to July 1982. The ratio of six-month to ten-year yields during the later period was 0.98. The largest comparable decrease was 38.9 percent from the nine-month average of 12.74 percent during February to October 1984 to the nine-year average of 7.78 percent during November 1985 to October 1994. That change was associated with a slope of 0.77 during the nine-year period.

The pattern of relatively flat yield curve slopes after interest rate increases and steep yield curve slopes after interest rate decreases is consistent with the data. In all nine-year periods in which the average ten-year CMT was above its average during the relevant earlier nine-month period, the yield curve slope was greater than 0.87. In all nine-year periods in which the average ten-year CMT was below its average during the relevant earlier nine-month period, the yield curve slope was less than 0.87. Furthermore, the greater the increase in the ten-year CMT, the flatter the yield curve slope tended to be, and the greater the decrease in the ten-year CMT, the steeper the yield curve slope tended to be. Results of an ordinary least squares regression imply that a sustained 75 percent increase in the ten-year CMT would likely result in a CMT yield curve slope of 1.00, while a sustained 50 percent decline provides an expected slope of 0.77.[148]

If the macroeconomic circumstances associated with a future shift in yields were to differ from those that engendered interest rate changes in recent decades, different results might easily occur. Nevertheless, the historical experience of the past four decades, as indicated both by the actual yield curve slopes in the episodes when the ten-year CMT changed most greatly and by the more general results, suggests an essentially flat yield curve in the up-rate scenario, and a curve with a relatively steep upward slope in the down-rate scenario.

Although the highest yield curve slope was 0.99, OFHEO chose a more straightforward yield curve slope of 1.00 for the up-rate scenario. The largest historical interest rate increase resulted in an almost flat yield curve, and that increase was still well below the increase of the up-rate scenario of the stress test. In addition to the six-month yields, OFHEO also proposes that all other key Treasury yields be equal to the ten-year CMT in the up-rate scenario. When the six-month CMT equals the ten-year CMT, setting all the other key

[147] In high yield environments, the changes in interest rates would be somewhat smaller, but past and recent data suggest that the changes will generally be of this magnitude.

[148] An ordinary least squares regression describes the results quantitatively. The dependent variable (Y_t) is the ratio of the average six-month CMT to the average ten-year CMT during the nine years ending in month t. The independent variable (X_t) is defined as the ratio of the average ten-year CMT in the nine years ending in month t to the nine-month average of the ten-year CMT from month t-128 to month t-120. The regression results are: $Y_t = 0.86 + 0.19\ X_t$.

Although this regression is based on monthly data over a 38-year period, it is a small data set for investigating this issue. The yield data start in December 1958, but each observation needs 128 months prior data, so the first observation used in the regression is August 1969. That leaves 326 observations through September 1996, but because of the lags, each observation is very similar to the one preceding it. There are really only four fully separate dependent variable observations. In these circumstances, the coefficient estimates are unbiased, but the usual regression statistics are not meaningful. In an alternative regression, the data were reorganized as follows. The 326 observations were rank-ordered by the independent variable and divided into quartiles. Using average values of the two variables from each quartile, the regression was rerun with the resulting four observations. The results are: $Y_t = 0.86 + 0.20\ X_t$.

Differences in parameter estimates from the full sample regression were small, less than 0.01, and the standard error of the coefficient of Xt was 0.022. Even though the observations for these regressions were limited, to the extent the data do exist, they support OFHEO's yield curve proposal.

Treasury yields equal to the same levels is straightforward and appropriate. In the down-rate scenario, however, setting the six-month and the ten-year yields does not directly suggest appropriate rates for instruments with other maturities. OFHEO proposes in this scenario that slopes of key CMTs to the ten-year CMT be based on a specific historical experience in a straightforward way that incorporates long-term relationships between yields of instruments with different maturities. The slope of the average six-month CMT to the average ten-year CMT during the nine-year period ending in April 1995 closely approximates the yield curve slope suggested by the regression equation.

Several commenters responded to a question in OFHEO's ANPR about the Treasury yield curve. Consistent with OFHEO's proposal, Fannie Mae recommended that OFHEO focus its approach to projecting yield curves on the ratio of the six-month Treasury yield to the ten-year Treasury yield. However, Fannie Mae recommended that the ratio of the six-month CMT to the ten-year CMT be set at a long-run historical average in both interest rate scenarios. Such an approach would not be consistent with actual experience that large sustained interest rate increases are accompanied by relatively flat yield curves and that large, sustained interest rate decreases are accompanied by relatively steep yield curves.

The Department of Veterans Affairs recommended a yield curve formula that would depend heavily on the shape of the yield curve at the start of the stress test. OFHEO considered such an approach, but found no evidence in historical data that the yield curve shape at the start of a ten-year period is related to the average shape over the final nine years of that period.

Freddie Mac suggested an approach based on an assumption that the statutory changes in interest rates represent a ''regime shift.'' As market participants adjust to the new regime, Freddie Mac argued, average yield curve relationships should return. OFHEO believes it is more appropriate to base projections of yield curve relationships on what has actually occurred in the past with the most similar changes in ten-year CMT levels.

NAR recommended that OFHEO take into account Treasury refunding behavior during the stress period. In order to keep the stress test as general as possible, OFHEO chose not to make any specific projections about Treasury debt issuance during the stress period.

c. Yields of Treasury Securities During the First Year

OFHEO proposes that during the first year of the stress period, the yields on Treasury securities of all maturities adjust linearly from their levels in the month proceeding the stress period to their levels during the final nine years of the stress period. In comments to OFHEO's ANPR, Fannie Mae stated that movements of the six-month and ten-year CMTs should be consistent during an adjustment period of one to two years. OFHEO agrees and believes its proposal will result in sufficiently consistent movement.

Freddie Mac suggested an approach under which, before the end of the first year, the yield curve might invert in the up-rate scenario and become very steeply upward sloping in the down-rate scenario. As previously discussed, OFHEO believes this approach is unnecessarily complex.

2. Yields of Non-Treasury Instruments

a. In General

Payments during the stress period associated with many Enterprise assets, liabilities, and derivatives contracts and the performance of mortgages, especially prepayment behavior, are dependent on future levels of yields on non-Treasury instruments and levels of non-Treasury interest rate indexes. OFHEO proposes to project these yield levels using econometric models relating non-Treasury interest rate series to yields on Treasury securities of comparable maturity.

The econometric specifications were based on two primary criteria. First, whenever possible, the non-Treasury interest rate series were modeled using the relative (rather than absolute) spread over comparable CMTs. Second, the specifications balanced the desire for simplicity with the need to account for the time-series properties inherent in the data.

Autoregressive integrated moving average (ARIMA) models were used to model the behavior of the non-Treasury interest rate series.[149] The models capture the average historical relationships between specific CMTs and non-Treasury interest rates. OFHEO believes this approach is consistent with recommendations of all commenters to a question on this issue in OFHEO's ANPR.

b. Yields on Enterprise Debt

OFHEO proposes that yields on Enterprise debt be projected in the same manner as yields on other non-Treasury instruments, except that a 50 basis point premium is added after the first year of the stress period. After one year of stress test conditions, the Enterprises might appear strong based on accounting measures of earnings and net worth. However, market values of the Enterprises' assets, liabilities, and derivatives contracts would fully reflect the effects of the interest rate shock and some of the credit quality deterioration of the stress test. Investors would be aware of these changes in market value and adjust their evaluations of the Enterprises' financial health accordingly. Because the Enterprises' ability to withstand further interest rate and credit shocks likely would be low, the Enterprises in the final nine years of the stress period would likely not meet their risk-based capital requirement and would, therefore, be subject to dividend restrictions. Such events might strengthen investor concerns about the Enterprises' financial health.

As government sponsored enterprises, the Enterprises likely would suffer much smaller debt market penalties than fully private firms in the same circumstances. However, the historical experiences of Fannie Mae and the Farm Credit System during periods of financial stress strongly suggest that borrowing costs would include some risk premium during economic conditions such as those in the stress test. As illustrated by data reported in the General Accounting Office's 1990 report on government sponsored enterprises, Fannie Mae's short-term

[149] An ARIMA (p,d,q) model implies p autoregressive terms, d differences of the original series, and q moving average terms. Generally speaking, differencing is undertaken to render a series ''mean-stationary,'' which is a requirement for statistical analysis of autoregressive models. For example, observations from a random walk include the cumulative effect of all past shocks (random disturbances) and/or trends. Differencing can net out the effect of persistent movements and make a series stationary. Autoregressive terms also represent the persistence of past shocks, but where the effect of the shock diminished over time. Moving average terms represent the effects of shocks that disappear completely after some finite number of periods.

In some situations the original series may also exhibit non-stationarity in the variance, requiring other normalizing transformations (e.g., taking logarithms). Also, visual examination of the data series and residual analysis based on appropriate statistical criteria (e.g., Ljung-Box Q-statistics) were used to guide the model selection process.

In some cases, a constant term has been included. This has the effect of preserving the historical average relative spread between the index and the corresponding Treasury rate when projecting future values. This is only done when there is some evidence that this historical difference is statistically significant. While differencing is necessary in many models to achieve stationarity in the mean, the use of relative spreads over Treasury rates of comparable maturities generally appears to make the original relative rate series variance stationary.

borrowing costs during 1980 through 1982 were generally about 80 basis points in excess of yields on comparable maturity Treasury debt, rising at one point to 200 basis points above Treasury yields. Spreads receded after sharp declines in interest rates greatly improved Fannie Mae's condition to a more normal range centered roughly at 20 basis points. Spreads were high again in the late 1980s for both Fannie Mae and the Farm Credit System, ranging from 40 to 100 basis points over a two-year period during the Farm Credit System's time of greatest financial difficulty.[150]

In stress test simulations based on the quarter ending in June 1997, the Enterprises' borrowing costs, including the 50 basis point premium, are 78 basis points above comparable Treasury yields in the up-rate scenario and 56 basis points above in the down-rate scenario after the first year of the stress period. Such spreads are appropriate because it is essential that the Enterprise be adequately prepared for widening debt yield spreads in periods of financial stress.

In its comments to OFHEO's ANPR, ACB pointed to Fannie Mae's difficulties in 1980 to 1982 as a possible basis for assessing likely borrowing spreads in the stress period. ACB also suggested that OFHEO might consider projecting the Treasury Department's use of its statutory authority to lend money to the Enterprises in stressful circumstances. OFHEO believes the stress test should assess the Enterprises' abilities to withstand the stress test without borrowing from the Treasury Department.

Freddie Mac commented that OFHEO should assume that the market's perception of an implicit government guarantee on Enterprise debt protects the Enterprises against any increased risk premium in borrowing spreads. OFHEO disagrees and believes the historical evidence is inconsistent with that view. OFHEO does agree that financial weakness of the Enterprises during the stress period should not be expected to have the same effect on borrowing costs that it would for firms that are not government sponsored enterprises. Nonetheless, some increase in risk premiums is appropriate. As the Enterprises' offering prospectuses clearly state, Enterprise obligations are not backed by the full faith and credit of the Federal government. OFHEO also agrees that attempting to calculate appropriate borrowing spreads at different times during the stress test, based on specific measures of Enterprise stress, would unnecessarily complicate the test. Accordingly, OFHEO proposes a constant risk premium during the final nine years of the stress period.

C. Mortgage Credit Enhancements

1. Background

The Enterprises use mortgage credit enhancements to reduce their credit risk exposure. For single family loans with LTV ratios in excess of 80 percent, the Enterprises must use certain statutorily enumerated credit enhancements. The Charter Acts prohibit the purchase of conventional single family mortgages with LTV ratios in excess of 80 percent unless: (1) the seller retains a participation interest of 10 percent or more; (2) the seller agrees to repurchase or replace the mortgage upon default (seller recourse); or (3) the amount of the mortgage in excess of 80 percent is insured or guaranteed.[151] Multifamily mortgages are not subject to such a requirement, but may also be credit enhanced.

The Enterprises currently use several different types of credit enhancements: (1) Private mortgage insurance on individual loans, which usually covers a percentage of the gross loss, or ''claim amount,'' [152] (2) seller recourse agreements, which require the seller/servicer to repurchase loans in the event of default, either for all loan defaults (unlimited recourse) or for all defaults up to a specified amount (limited recourse); (3) indemnification, which requires the seller/servicer to reimburse the Enterprises for losses (either unlimited or limited) on defaulted loans after final resolution by the Enterprise; (4) pool insurance, which covers losses on a pool of loans up to a specified percentage of the aggregate unpaid principal balance (UPB), usually after private mortgage insurance has been applied; (5) spread accounts maintained by the Enterprise or a custodian to offset losses, funded by part of the spread between the interest rate on the loans in a pool and the coupon passed through to the investor; (6) collateral pledge agreements under which the Enterprise obtains a perfected interest in securities held in an account (usually Treasury securities or mortgage-backed securities), to offset losses on a pool of loans when a seller/servicer hits certain financial triggers or when the loans are high risk; and (7) cash accounts funded by the seller/servicer that are available to offset losses.

2. Modeling Approach

The stress test calculates the loss coverage provided by credit enhancements in one of two ways, depending on the credit enhancement type. Private mortgage insurance, unlimited recourse, unlimited indemnification, and risk-sharing agreements provide coverage for a percentage of the loss incurred. The dollar value of these credit enhancements is not known at the beginning of the stress period because it depends on the size of the loss that occurs in the future. What is known is the percentage of the loss that will be covered. Therefore, these credit enhancement types are referred to herein as ''percent-denominated'' enhancements. The other credit enhancement types are referred to as ''dollar-denominated'' enhancements, because the total coverage provided can be expressed in dollar amounts without knowing the size of the losses in advance.

The stress test applies the loss coverage provided by credit enhancements to the loan groups into which individual loans have been aggregated for modeling efficiency. (*See* section II. A., Summary of the Stress Test, for a description of the characteristics that are the basis for aggregation.) The loss coverage is a weighted average of the credit enhancements applicable to any loans in the group. In situations where a loan group is covered by both percent-denominated enhancements and dollar-denominated enhancements, the two different types of credit enhancements are applied sequentially. First, the loss severity of a loan group is reduced by an amount that is determined by the percentage coverage of the applicable percent-denominated credit enhancements. Then, the dollar coverage available from dollar-denominated credit enhancements is applied to the remaining losses on the loan group until all of the available dollar coverage for that loan group is used up. This approach permits percent-denominated credit enhancements (such as private mortgage insurance) to be applied before dollar-denominated credit enhancements (such as pool insurance) are applied, capturing the benefits of multi-layered credit enhancements.

[150] U.S. General Accounting Office (1990), *Government Sponsored Enterprises: The Government's Exposure to Risk*, Washington, DC: U.S. General Accounting Office, (GAO/GGD–90–97) 87–88.

[151] *See* sections 305(a)(2) and (4)(C) of the Federal Home Loan Mortgage Corporation Act (12 U.S.C. 1454(a)(2) and (4)(C)) and sections 302(b) and (5)(C) of the Federal National Mortgage Association Charter Act (12 U.S.C. 1717(b)(2) and (4)(C)).

[152] The claim amount includes the defaulted principal balance, unpaid interest, and associated expenses. It does not reflect subsequent proceeds from the sale of REO.

Some dollar-denominated enhancements provide coverage in a dollar amount that is fixed and known at the time the agreement is executed. These include pool insurance, limited recourse, limited indemnification, and cash accounts. Other dollar-denominated enhancements provide coverage in a dollar amount that is subject to variation during the term of the agreement. These include spread accounts and collateral pledge agreements. Changes in these balances due to reasons other than loss coverage are not modeled. Rather, balances are treated as cash [153] and drawn upon after dollar losses are determined, until the total amount is exhausted.

Some credit enhancements, namely private mortgage insurance, recourse, pool insurance, and indemnification, are subject to the institutional credit risk of the provider, i.e. the risk that the counterparty providing the credit enhancement will default on its obligation. Where institutional credit risk is present, the stress test applies a discount factor, or ''haircut,'' based on the credit rating of the counterparty.

The haircuts that have been adopted by OFHEO are set forth by rating category in Table 27:

Table 27. Rating and Cumulative Haircut

Month	AAA	AA	A	< = BBB
12	1%	2%	4%	8%
24	2%	4%	8%	16%
36	3%	6%	12%	24%
48	4%	8%	16%	32%
60	5%	10%	20%	40%
72	6%	12%	24%	48%
84	7%	14%	28%	56%
96	8%	16%	32%	64%
108	9%	18%	36%	72%
120	10%	20%	40%	80%

The haircuts reflect the probability that some counterparties will be unable to meet their obligations during the stress period. Haircuts become progressively larger as the counterparty rating decreases, with parties rated BBB or lower and unrated parties receiving the most severe haircut. The haircut for each rating category is cumulative rather than additive. It increases for each month of the stress period, beginning in the first month of the stress test and increasing by equal amounts (i.e., linearly), until the full amount of the discount is reached in the 120th month. Table 27 reflects the size of the haircut at the end of each 12-month period during the stress period. Rating downgrades are not modeled. Instead, deterioration in the financial condition of counterparties due to the stressful environment is reflected in the linear increase of the haircuts.

3. Comments and Alternatives Considered

In the ANPR, OFHEO requested comments on how to calculate the loss coverage provided by credit enhancements and on what assumptions to make about the scope of coverage and the failure of counterparties during the stress period. These and other issues, relevant comments received, and OFHEO's rationales for the selected approaches are discussed below.

a. Modeling Approach

ANPR commenters suggested a variety of modeling approaches. MICA stated that the capital requirements for the Enterprises should be consistent with capital requirements for banks and thrifts and reflect the underlying product risk associated with each class of mortgage-related assets. MICA recommended that OFHEO assign relative ''capital relief'' values to ''the three allowable credit enhancements'' [154] based on the quantity and quality of the credit enhancement. MICA further recommended that OFHEO consider mortgage insurance provided by a company with at least a AA claims-paying rating and providing at least the minimum coverage required by the Enterprises' charters as the ''benchmark credit enhancement.'' The benchmark credit enhancement should receive the ''maximum amount of capital relief,'' and other forms of credit enhancement should receive values relative to this benchmark, based on the quality and quantity (i.e. the amount of the loss it covers) of the enhancement. (*See* section III.C.3.c., Discounting for Counterparty Risk for a discussion of MICA's comments related to the quality of the credit enhancement.) MICA views this approach as consistent with risk-based requirements for banks and thrifts, which require uninsured high-LTV loans

[153] Although dollar balances for these types may in reality vary during the stress period, the stress test uses the balance stated at the beginning of the stress period.

[154] OFHEO interprets ''three allowable credit enhancements'' as a reference to the three types of credit enhancement mentioned in the Charter Act exception to the prohibition on purchasing loans with LTVs in excess of 80 percent.

held in portfolio to have twice as much capital as high-LTV loans that are privately insured.

Freddie Mac suggested a two-step process similar to the process it uses in its internal models for pricing transactions. Freddie Mac first estimates the value of the credit enhancement by estimating the proportion of default losses that would be covered, and then discounts the estimated value to reflect the institutional credit risk of the provider, if any. Although Freddie Mac's credit enhancement valuation process occurs at the transaction level for pools of mortgages, Freddie Mac suggested that such a transaction-level approach might not be well suited for OFHEO's stress test. Rather, it recommended aggregating credit enhancements into categories before applying the two-step process. Freddie Mac further recommended that private mortgage insurance be modeled in connection with the modeling of loss severities. Other types of credit enhancements, Freddie Mac suggested, could be converted to ''collateral-equivalent'' amounts and, after discounting for applicable institutional credit risk, aggregated into a large collateral-equivalent pool and used to offset stress test losses dollar for dollar. Freddie Mac made specific recommendations for collateral-equivalent conversions: collateral pledge agreements and spread accounts should be included on a dollar-for-dollar basis and future inflows to spread accounts should be estimated based on the weighted average life (WAL) of the pool; [155] pool insurance should be included to the policy limit, i.e. the percentage limitation multiplied by the original UPB; and recourse and indemnification agreements should be treated as if 100 percent of the losses from mortgage defaults in the applicable pools were covered until such time as the seller/servicer failed.

The approach adopted by OFHEO is similar in many respects to the approach suggested by Freddie Mac. Like Freddie Mac's approach, it estimates the probable coverage of credit enhancements and discounts for counterparty risk where it is present. The value of private mortgage insurance and other forms of credit enhancements that cover a percentage of loss is estimated in connection with loss severities, as suggested by Freddie Mac. The approach adopted by OFHEO differs from the approach suggested by Freddie Mac in some of the details of how credit enhancement coverage is estimated and how discounts for counterparty risk are calculated. These differences are discussed further below.

b. Aggregation

A threshold issue for OFHEO was whether to track and model each credit enhancement with the loan or pool to which it relates or to use some level of aggregation for credit enhancements to increase modeling efficiency. Tracking and modeling each individual credit enhancement agreement with the particular loan or pool to which it is related would yield the most precise estimate of the value and behavior of credit enhancements, but would make the model very complex. Aggregating credit enhancements for efficiency in modeling, on the other hand, gives rise to ''cross support,'' which overestimates the amount of credit enhancements that would actually be used to offset losses. ''Cross support'' means that credit enhancements provided on a particular loan or pool are available to offset losses on another loan or pool, when in practice they would be available only to offset losses on the particular loan or pool for which they were provided and would be partially unused if losses were lower than the amount of the coverage. However, in a model that aggregates credit enhancements and applies them to loan groups, the unused portion of a credit enhancement is available to cover losses in the same loan group. The greater the aggregation of credit enhancements in the stress test, the more cross support occurs, and the more the estimated value of the credit enhancements is overstated. Aggregation up to a very high level can introduce an unacceptable level of cross support.

OFHEO considered converting each credit enhancement type to a dollar-equivalent amount, aggregating these amounts across all credit enhancement types into a single pool of collateral-equivalent dollars, and applying them dollar for dollar against stress test losses. While this approach is simpler and would have required less intensive tracking, it would permit an unacceptable level of cross-support by credit enhancements of different types and for different loan groups. Just as importantly, this approach would not have produced accurate results for the coverage associated with percent-denominated credit enhancements, such as private mortgage insurance. The dollar amount of coverage of these credit enhancements cannot be calculated until losses are determined. These losses can only be calculated during the course of the stress period; they are not known at the beginning of the stress period.

The approach adopted by OFHEO strikes a balance between the benefits of simplicity and efficiency and the benefits of precision while imposing minimal regulatory burden. By estimating the coverage provided by each type of credit enhancement on the basis of loan groups, tracking credit enhancements for each loan group can be accomplished efficiently. The large number of loan groups used by the stress test minimizes cross support between different types of credit enhancements, loans, and time periods.

c. Discounting for Counterparty Risk

Another issue faced by OFHEO was whether and how to take into account the risk that the counterparty's ability to perform on the credit enhancement agreement would be affected by the conditions of the stress test.

OFHEO received a number of suggestions on the treatment of counterparty risk in response to the ANPR. Freddie Mac, MICA, and ACB recommended incorporating an assumption that some of the counterparties would fail during the stress period and suggested that OFHEO look to private rating agencies for guidance. ACB suggested that the OFHEO analysis of the actual coverage provided by mortgage insurance during the stress period could be ''piggybacked'' on S&P's analysis. ACB further stated that OFHEO could make reasonable adjustments to align the worst-case scenario in S&P's stress test with that in the OFHEO analysis, and that it would not be necessary to extend the analysis beyond private mortgage insurers.

As noted earlier, MICA recommended a matrix for determining ''capital relief'' for credit enhancements relative to a benchmark credit enhancement. One dimension of the recommended matrix is the credit rating of the counterparty, reflecting an assumption that the values assigned to various credit enhancements should reflect a differentiation on the basis of the provider's claims-paying rating. However, MICA's recommendation that OFHEO give ''maximum capital relief'' (at least 50 percent of the normal capital charge) to a AA-rated insurer providing at least the minimum coverage required by the Enterprises' charters appears to be equivalent to a recommendation that AA-rated counterparties not be discounted at all.[156] MICA asserted that

[155] This could be done by multiplying the WAL by the average yearly spread going into the spread account and then by the UPB.

[156] The risk-based capital requirements for banks and thrifts are not determined by a statutorily prescribed stress test but by establishing a standard

this recommendation is supported by the historical default experience for corporate bonds in the 1970–89 period, particularly the 0.9 percent default rate for AA-rated bonds.[157] From this MICA concluded that 99.1 percent of mortgage insurance would be available to the Enterprises during the stress period.

Freddie Mac recommended that evaluation of counterparty risk be based on the probable length of time an institution would continue meeting its loss-paying obligations in the stress period, which would be determined by the institution's rating at the beginning of the stress period. This method, Freddie Mac asserted, is similar to one used by Moody's. Specifically, AAA-rated companies would be assumed to cover all obligations for the entire ten-year stress period. AA-rated companies would be assumed to cover all obligations for seven years and none thereafter, A-rated companies for five years, and companies rated BBB and lower, only three years. Freddie Mac also recommended that institutions that are required to post collateral under a collateral pledge agreement be ranked with AAA-rated institutions. For recourse and indemnification agreements, Freddie Mac suggested that OFHEO could assume the agreement would last until the institution failed, a time determined by the institution's rating. It noted, however, that a similar effect could be achieved by adjusting the loss severities based on institution ratings, where the adjustment to loss severity would be lower for a higher institutional rating. However, Freddie Mac cautioned that if this approach were used, the difference between the present-value cost of losses occurring at the end of the stress period and losses occurring at the beginning of the stress period would have to be taken into account. That is, an institution that honors its recourse agreement for the first five years of the ten-year stress period would pay out much more than half of the present value of the losses.

Only one commenter suggested that credit enhancements having counterparty credit risk not be discounted for the risk. The MBA expressed concern about the burden it would place on the Enterprises to determine the financial strength of third parties and suggested that credit enhancements need not and should not be discounted for credit risk of the counterparty. The reasons cited were three. First, the Enterprises generally accept credit enhancements only from well-capitalized companies. Moreover, the Enterprises are in a good position to evaluate the counterparty's financial strength,[158] and the seller/servicer agreement often provides added protection from default on repurchase or indemnification obligations. Second, an assessment of counterparty credit risk is reflected in guarantee fees, which can be adjusted with each commitment. And third, mortgage insurers are nationally rated by recognized organizations that routinely adjust ratings based on changes in financial status. As a result, trends in their financial health can be monitored easily. The MBA urged OFHEO to ground its assumptions and conclusions in historical experience and ''real world'' conditions, which, in its view, argue for not discounting credit enhancements for counterparty risk.

OFHEO believes that some counterparty failure would be likely under the stressful conditions imposed by the stress test and that discounting for counterparty credit risk is necessary to avoid overstating the effect of credit enhancements in covering losses. The statutorily required benchmark stress period is considerably more severe than the national historical experience of corporate bonds cited by MICA. Also, as noted by Anthony Yezer, Professor of Economics at George Washington University, the failure of private mortgage insurers was important in the collapse of the thrifts in the 1930s.

Although the stress test reflects assumptions about the claims-paying abilities of counterparties during the stress period that are similar to Freddie Mac's, OFHEO did not adopt Freddie Mac's assumption that counterparties would pay 100 percent of their obligations as long as they paid at all. In OFHEO's judgment, this assumption is inconsistent with the pattern of counterparty defaults on obligations that one would expect during a stressful period and inconsistent with the pattern of defaults observed in the past. For example, Moody's study of corporate bond defaults[159] showed that cumulative defaults in each of the various ratings categories increased gradually over time. Also, it is likely that the primary market and credit enhancement counterparties would be affected by the stress test conditions relatively early in the stress period. Freddie Mac's approach would not capture this early impact. If mortgage losses were to occur during the first half of the stress period, the importance of reductions in credit enhancements due to counterparty risk would be understated because, as noted by Freddie Mac, mortgage losses occurring during the first half of the stress period constitute much more than half of the present value of total losses. Therefore, credit enhancements offsetting those losses would be more valuable. A more realistic assumption is that the rate of counterparty defaults would increase gradually during the stress period.

OFHEO did not adopt Freddie Mac's recommendation to treat seller/servicers who are required to post collateral when certain financial triggers are met[160] the same as AAA-rated institutions. Freddie Mac contends that the existence of these agreements would provide coverage equivalent to a AAA-rated credit enhancement. However, whether collateral would actually be posted when required is an additional source of counterparty risk and whether that collateral would provide coverage equivalent to a AAA-rated credit enhancement is difficult to evaluate in a regulatory context. Such an evaluation would require OFHEO either to develop the capacity to rate each seller/servicer with a collateral pledge agreement and the impact of the agreement on the seller/servicer's rating, or to require the Enterprises to obtain public ratings for such seller/servicers that take these agreements into account. In light of the small impact that this degree of precision is likely to have on the capital requirement, OFHEO believes that developing such a rating capacity is not an appropriate use of regulatory resources, and that requiring the Enterprises to obtain public ratings would impose an undue regulatory burden. Consequently, the proposed stress test does not model the value of collateral pledge agreements. Instead, it only models coverage provided by collateral that is already available in an Enterprise or third-party account.

This treatment is consistent with the treatment of such agreements under OFHEO's minimum capital regulation. Collateral is not recognized for purposes

capital charge for all assets that is expressed as a fixed percentage of the face amount of the asset. Capital relief for particular assets is achieved by risk weighting them at less than 100 percent of the face amount. Risk-based capital regulations for banks and thrifts risk-weight mortgage loans at 50 percent of the UPB. In a stress test regulation, the most favorable capital treatment is achieved by giving full credit for the credit enhancement without any discount.

[157] ''Approach to Rating Residential Mortgage Securities,'' Moody's Investor Service, April 1990.

[158] This results, MBA noted, from close relationships between the Enterprises and seller/servicers based on frequent marketing contacts, Enterprise auditing activities, and lender reporting obligations.

[159] ''Historical Default Rates of Corporate Bond Issuers, 1920–1997,'' Moody's Investors Service, February 1998.

[160] Seller/servicer agreements may include such a requirement when there is a decline in the institution's rating or a decline in its capital levels below a specified amount.

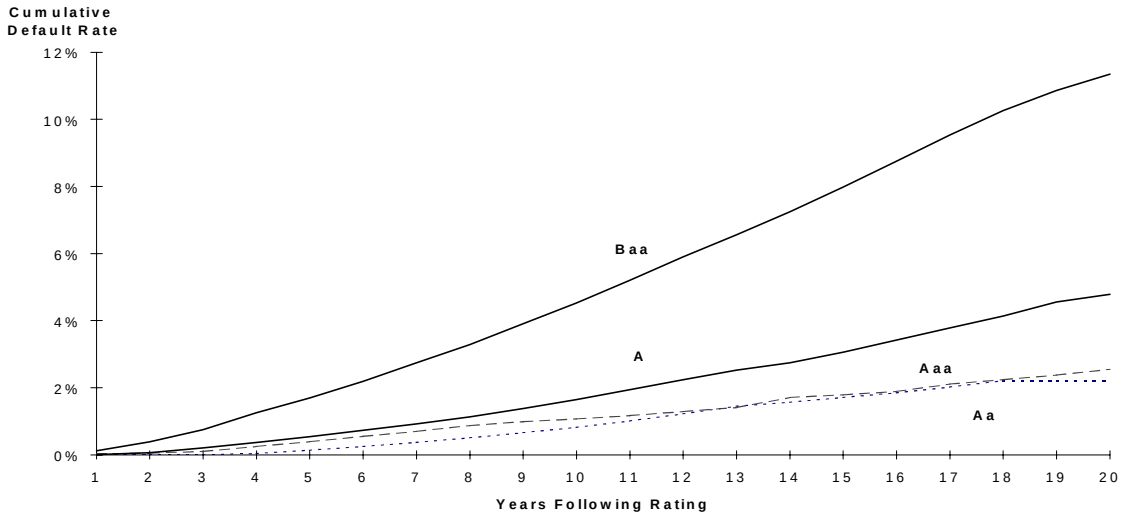
of satisfying the minimum capital standard unless it is actually held and legally available to absorb losses. Also, to be consistent with the minimum capital restrictions on the forms of collateral that are acceptable, the proposed stress test will give credit for the coverage provided by collateral only if it is among the following types: cash on deposit; securities issued or guaranteed by the central governments of the OECD-based group of countries,[161] United States Government agencies, or United States Government-sponsored agencies, and securities issued by multilateral lending institutions or regional developments banks.

In determining the size and timing of the discounts (haircuts) to the value of the credit enhancements, OFHEO considered Moody's study of corporate bond default rates and methodologies used by S&P and Duff & Phelps (D&P). Moody's analysis of corporate bond issuers from 1920 to 1997 [162] showed cumulative default rates over various time horizons for each rating category. The average ten-year cumulative default rate over the entire period was 1.17 percent for Aaa issuers, 3.32 percent for Aa issuers, 3.87 percent for A issuers, 8.08 percent for Baa issuers. These data suggest that the ten-year cumulative default rate roughly doubles for each one-level drop in rating category. Defaults for Aa issuers were higher relative to those for Aaa and A issuers than this doubling relationship would suggest. However, Aa issuers from the mid-1970s forward had ten-year cumulative default rates that were much lower relative to issuers in other rating categories.

The Moody's approach and the approach recommended by Freddie Mac is a survival approach in which it is assumed that an institution meets 100 percent of its obligations for as long as it survives, and relative risk is expressed as the number of years an institution survives. The approach used by S&P and D&P [163] is a haircut approach in which it is assumed that institutions will meet some, but not all, of their obligations, and the haircut is the percent of obligations they will fail to meet. Specifically, S&P discounts the claims-paying ability of mortgage insurers in a AA stress level environment by 20 percent for AA-minus-rated mortgage insurers, 50 percent for A-rated mortgage insurers, and 60 percent for A-minus-rated mortgage insurers. D&P discounts mortgage insurers in a AAA stress level environment by 35 percent for AA-rated reinsurers, 70 percent for A-rated reinsurers, and 100 percent for BBB-rated reinsurers. For S&P, the haircuts apply in full from the second year of the stress period. Also, the haircut is related to the stress level of the environment, and an insurer with a rating equal to or greater than the stress level is not discounted.

Moody's corporate bond study shows that the cumulative default curves for companies with ratings of BBB and above were essentially linear.

Figure 2. Cumulative Default for Corporate Bonds by Rating Category



OFHEO's approach to applying haircuts is similar to S&P's and D&P's, but differs in three ways. First, the stress test does not apply the full amount of the haircut immediately but applies a haircut that increases each month until reaching the full amount in the 120th month. This reflects the general industry view that defaults increase gradually in a stress scenario. Further, as illustrated by the graph in Figure 2, the linear growth specification of the stress test is a reasonable one in light of actual historical patterns of default. Second, the stress test haircuts are in no case as low as zero and in no case as high as 100 percent. This reflects historical default patterns, which suggest that counterparties or issuers in each rating category would pay at least some claims, and no rating category would be immune from any claims-paying defaults. With respect to the absence of a rating category with zero defaults, Moody's data show that, in a difficult but far from severe environment, 3.2 percent of issuers rated

[161] The OECD-based group of countries comprises all full members of the Organization for Economic Cooperation and Development and countries that have concluded special lending arrangements with the International Monetary Fund (IMF) associated with the IMF's General Arrangements to Borrow, but excludes any country that has rescheduled its external sovereign debt within the previous five years.

[162] ''Historical Default Rates of Corporate Bond Issuers, 1920–1997,'' Moody's Investors Service, February 1998.

[163] ''S&P's Structured Finance Criteria,'' Standard & Poor's Corporation, 1988; ''Evaluation of Mortgage Insurance Companies,'' Duff & Phelps, November, 1994.

Aaa at the beginning of 1983 defaulted within 10 years. Third, the stress test haircuts are not tied to the stress level. While OFHEO's NPR 1 showed credit stress at roughly a AA+ level, the stress test as a whole does not translate to any particular level because OFHEO's methodology as required by the 1992 Act differs in several key respects from that used by rating agencies.

Although OFHEO considered developing a probabilistic survival function for counterparties that would provide an estimate of failure in each year of the stress period, such a methodology would be difficult to specify, implement, and replicate, especially if recovery rates on bankrupt counterparties were modeled. OFHEO concluded that, short of a probabilistic function, imposing a linearly increasing haircut on all counterparty credit enhancement proceeds through the entire stress period would be the most representative of all the other options of how the rate of counterparty defaults would increase during the ten-year stress period.

The size of the haircuts proposed for the stress test, ten percent for AAA-rated companies, 20 percent for AA-rated companies, 40 percent for A-rated companies, and 80 percent for BBB-rated companies, are far more severe than recent default experience but less severe than Depression-era experience. They are about six to ten times the severity of average ten-year cumulative defaults during 1920–1997 in the Moody's analysis. The haircuts double for each drop in rating category, consistent with the Moody's bond default analysis. Some default occurs among AAA-rated companies, while BBB-rated company defaults are not 100 percent.

OFHEO's approach is transparent, easily replicated, and consistent with industry practice. It draws on the best aspects of S&P's approach to modeling mortgage insurer performance, and Moody's corporate bond study in applying company defaults over time. It also recognizes that, while the impact of the stress test environment on Enterprise losses might not be large in the first two years of the stress period, the primary mortgage market (i.e., the seller/servicer counterparties) likely would feel the impact of a stressful environment almost immediately.

d. Unrated Seller/Servicers

OFHEO considered whether unrated seller/servicers should be treated the same as other unrated counterparties or whether they should be treated differently because of their close relationships with the Enterprises.

Both Freddie Mac and MBA argued that even though seller/servicers are typically unrated, the close relationship between the Enterprise and its seller/servicers enables the Enterprise to monitor their financial strength. Freddie Mac stated that the seller/servicer agreement provides added protection against default on recourse and indemnification obligations because it gives Freddie Mac the right to the servicing of all Freddie Mac loans then serviced by the institution in the event of default on these obligations. Freddie Mac asserted that the value of the servicing is likely to cover a substantial portion of the defaults covered by a seller/servicer recourse agreement.[164] For these reasons, Freddie Mac considers all sellers/servicers to be at least BBB for purposes of evaluating institutional credit risk and urged OFHEO to consider the added layers of protection provided by the servicing rights.

The stress test treats unrated seller/servicers, like other unrated counterparties, the same as it treats BBB counterparties, which is consistent with the thrust of Freddie Mac's ANPR comments. Although OFHEO does not explicitly price the added layer of protection provided by mortgage servicing rights in its stress test, this added layer of protection was considered as a factor in deciding that unrated counterparties should be treated as BBB. OFHEO believes that any imprecision resulting from assigning unrated seller/servicers to the BBB or lower rating group would have a small impact on the resulting capital requirement. Seller/servicer recourse represents a small percentage of the credit enhancements used by the Enterprises. In addition, the Enterprises' largest customers tend to have public ratings.

Although the Enterprises assign internal ratings to seller/servicers, OFHEO did not use these ratings for three reasons. First, these ratings and the methodology for developing the rating are proprietary information and not publicly available. Therefore, they cannot be included in the regulation or used by third parties to evaluate the risk-based capital requirement. Second, each of the Enterprises has developed its own unique rating system. These rating systems may result in different ratings of the same parties. One of the underlying requirements of this regulation is the development of a capital requirement that is applied uniformly to both Enterprises. This requirement cannot be met if different rating systems are applied to each Enterprise. Finally, using such ratings without independent validation by OFHEO would compromise the independence of the regulatory process.

e. Fluctuations in Value

The dollar value of some credit enhancements, such as spread accounts and securities deposited in an account under collateral pledge agreements, fluctuate over time, for reasons other than withdrawals to cover losses. Spread accounts are funded by a portion of each loan payment and hence increase in value as loan payments are made. Securities deposited in an account under collateral pledge agreements,[165] which are marked to market periodically, fluctuate in value due to movements in interest rates during periods that fall in between the marks to market. In addition, posting requirements of collateral pledge agreements can cause additional collateral to be deposited to the account.

The stress test does not model these fluctuations. Rather, it uses the dollar value of spread accounts, cash accounts, and collateral posted under collateral pledge agreements on the first day of the stress period and draws on this dollar amount throughout the stress period to cover losses. Modeling fluctuations in the value of collateral posted under collateral pledge agreements would have added a level of complexity that is not justified by the incremental precision that would be gained. Similarly, the stress test does not model the accumulation of interest in the spread account according to the terms of the spread account agreement because this would have introduced a level of complexity that is not justified by the probable impact on the ultimate capital requirement.

Freddie Mac suggested that OFHEO estimate future inflows by multiplying the weighted average life (WAL) of the mortgage pools by the average yearly spread going into the spread account and then by the UPB. However, such an approach would also have made the stress test excessively complex. Loans covered by a spread account agreement may be in different loan groups in the stress test, and determining the WAL of all the loans covered by each spread account would require tracking each

[164] Freddie Mac estimates that these servicing rights are normally worth about 25 basis points of income per year, and can be sold to another servicer for 100 to 150 basis points.

[165] As stated earlier, the stress test recognized the coverage provided by collateral pledge agreements only if collateral has actually been posted and resides in an account as of the beginning of the stress period. Otherwise, collateral pledge agreements are not modeled in the stress test.

spread account loan and processing spread account characteristics at the transaction level.

OFHEO will continue to monitor the relative volume of spread accounts and collateral pledge agreements and consider whether an amendment to the regulation is needed if it should appear that the impact on the capital requirement might be significant.

f. Credit Enhancement on High LTV Loans

Certain credit enhancement types used by the Enterprises are not mentioned in the Charter Acts' exceptions to the prohibition on purchasing single family loans with LTVs in excess of 80 percent, namely spread accounts, collateral pledge agreements, cash accounts, pool insurance, and indemnification. This fact raised the issue of whether the stress test should take them into account when they are intended to satisfy the statutory requirement for credit enhancement on loans with LTVs in excess of 80 percent. In its comment letter, Freddie Mac argued that an expansion of the list of recognized credit enhancements to include collateral pledge agreements, spread accounts, and indemnification would be consistent with the intent of Congress in giving the OFHEO Director discretion to make reasonable assumptions about factors that would affect the severities of loss on mortgage defaults, including ''the value of mortgage insurance [and] the value of various forms of credit enhancements such as recourse agreements, collateral, and spread accounts.'' [166] MICA, on the other hand, argued that only the three types mentioned in the statutory exceptions should be considered.

Although OFHEO recognizes that some types of credit enhancements not expressly referenced in the Charter Acts may provide equal or superior loss protection, OFHEO does not believe that they satisfy the statutory requirement for credit enhancements for single family loans with LTVs in excess of 80 percent. OFHEO does not concur with Freddie Mac that the legislative history of the 1992 Act gives OFHEO the latitude to expand the list of statutorily authorized credit enhancements for single family loans with LTVs in excess of 80 percent. OFHEO believes that taking into account credit enhancements not expressly referenced in the Charter Acts when they are used to satisfy the statutory credit enhancement requirement for single family loans with LTVs in excess of 80 percent would undermine OFHEO's efforts to ensure that the Enterprises operate within the Charter Acts.

g. Scope of Coverage

The ANPR asked for comments on how the regulation should address the scope of coverage provided by credit enhancements. Freddie Mac, the only commenter on this question, stated that all credit enhancements except private mortgage insurance can be assumed to cover all loss elements, including loss of property value, lost interest, real estate commissions, attorney fees, taxes, and preservation costs, where as private mortgage insurance sometimes excludes certain expenses after the property becomes REO.

Based on an analysis of available information, OFHEO proposes to make credit enhancements coverage available for all types of losses associated with stress test defaults. The benchmark data reveal that loss severities before credit enhancements were applied for single family loans in the benchmark time and place were consistently in the 50 percent to 60 percent range. At the same time, private mortgage insurance coverage typically ranged from 12 percent to 30 percent coverage of the gross claim amount. Since the severities far exceed the coverage of private mortgage insurance, the stress test assumes that the private mortgage insurance would be used up covering expenses that the mortgage insurance typically covers, and that the REO-related expenses would be reflected in the uncovered losses.

h. Termination of Private Mortgage Insurance

Modeling private mortgage insurance required a determination of how to treat the potential for termination of mortgage insurance while the loan is outstanding. Termination occurs either because the borrower exercises an option to cancel the insurance when the equity in the loan reaches a predetermined threshold, or because cancellation is automatic under the provisions of the recently enacted Homeowners Protection Act of 1998.[167] For loans originated before the July 1999 effective date of the Homeowners Protection Act, termination resulting from the borrower's exercise of the right to cancel the insurance when sufficient equity in the loan is attained presents a difficult issue, because data on this phenomenon are scarce, and there is an insufficient basis on which to draw firm conclusions. OFHEO considered three options: (1) assume that borrowers do not exercise this right when they are eligible; (2) assume all borrowers exercise this option when they become eligible; or (3) assume some percentage of borrowers, less than 100 percent, exercise this option when they become eligible.

After considering these options, OFHEO concluded that the first option was the preferred option because it is the option likely to produce the least distortion. The second option would understate the amount of credit enhancement available and the third would require an assumption based on very sparse data. Although assuming that insurance is not terminated may be a source of some imprecision, the impact of such imprecision is not likely to be significant in determining capital needed under the stress test. The loans most likely to default are those loans with high current LTV ratios, which will not be eligible for termination of private mortgage insurance because of the high LTVs. Conversely, those loans with low enough current LTV ratios to be eligible for termination are much less likely to need the coverage, and whether it is unused or is assumed to be terminated will make little difference. The largest potential for error is with loans with high original LTV ratios that have aged prior to the stress test just to a point where coverage can be terminated. OFHEO will monitor this issue and consider proposing an amendment to the regulation if another option appears to be more appropriate.

The Homeowners Protection Act provides that mortgage insurance will terminate automatically when the loan balance is scheduled to reach 78 percent of the original value of the property securing the loan, provided payments on the loans are current. For loans that do not meet the LTV test and for high-risk loans with original principal balances that do not exceed the conforming loan limit, mortgage insurance will terminate when the loans reach the mid-point of their amortization periods if payments are current. The Enterprises will publish guidelines to describe high-risk loans. OFHEO proposes to apply the provisions of the Act by eliminating mortgage insurance coverage in calculating loss severities for loans that reach 78 percent of their original value during the stress period or at the midpoint of their amortization periods for ''high risk'' loans, as defined by the Enterprises.

D. Liabilities and Derivatives

The Enterprises issue a variety of debt instruments that comprise their liability

[166] H.R. Rep. No.102–206, at 67 (1991).

[167] Pub. L. No.105–216, 112 Stat. 897–910 (12 U.S.C. 4901–4910).

portfolios. To understand the types of liabilities issued by the Enterprises it is useful to group the liabilities into categories based on similar characteristics related to the instrument's coupon type, optionality, or other structuring features. The liabilities issued by the Enterprises are primarily one of three coupon types: fixed-rate, floating-rate, or zero-coupon. The Enterprises use these different types of coupons to manage both their exposure to interest rate risk and their cost of funding. The optionality of a financial instrument refers to whether that instrument contains an embedded option—in the case of the Enterprises liabilities, generally a call option. The embedded call option gives the Enterprises the opportunity to pay off (call) the debt, at a time prior to its contractual maturity. The Enterprises issue a mix of callable and non-callable (bullet) debt in order to manage their exposure to the prepayment risk inherent in their retained mortgage and mortgage security portfolios.

The Enterprises also issue liabilities that have unique structuring features, such as complex principal, coupon, or optionality characteristics. An example of a complex liability is a Euro discount note. To the extent that these notes are issued in foreign currencies, the Enterprises are exposed to foreign exchange risk, which is offset with hedging transactions at the time the discount notes are issued. An example of a liability with complex coupon characteristics is an inverse floater. For example, this instrument may pay a fixed rate of interest for a given period of time and then revert to an interest payment based on the formula 12 percent less six month LIBOR. In this case, the Enterprises incur higher interest costs as LIBOR decreases. In most situations, the complex risk characteristics of these liabilities are hedged at the time of issuance, leaving the Enterprise with synthetic ''plain vanilla'' liabilities, which have the coupon and option features of a more typical Enterprise liability. These liabilities generally are used by the Enterprises to obtain funds at a lower net cost than could be obtained by issuing simpler forms of debt.

In addition to the types of liabilities discussed above, the Enterprises also provide investment vehicles, termed Guaranteed Investment Contracts (GICs), to various institutions that have specific cash flow requirements or need flexibility in making cash withdrawals. They comprise a very small percentage of the Enterprises' liabilities. GICs can pay or accrue interest. Their principal balances can increase, decrease or remain the same.

The Enterprises, like most large financial institutions, use derivatives to help manage the interest rate risk of their assets and liabilities. The term ''derivatives'' covers a broad range of instruments, the value of which is based on or linked to (i.e., ''derived'' from) another instrument or a financial market such as stocks, interest rates or currencies. A common derivative is an interest rate swap, which derives its value from the changes in value of interest rates paid on various types of debt instruments. Derivatives can be used to hedge the unusual or complex risk characteristics of individual debt instruments, such as the complex structured liabilities described above. They also can be used to rebalance the interest rate risk of an entire portfolio. In short, derivatives, like most financial instruments, can either add or reduce various types of risk. The risk-based capital regulation, therefore, must account for derivatives in order to reflect accurately the risk profile of the Enterprises.

In developing an approach for modeling the cash flows of the Enterprises' liabilities and derivatives, OFHEO had to address four issues discussed below: (1) should liabilities and derivatives be modeled at the instrument level or should they be aggregated in some manner; (2) how should instruments linked to foreign currencies or unusual risk factors be modeled; (3) how should callable debt and cancellable derivatives be modeled; and (4) how should the stress test account for the risk of derivative counterparty defaults?

1. Modeling Methodology

The first issue for OFHEO was whether to model liability and derivative cash flows at the instrument level or to aggregate individual instruments with similar terms and risk characteristics and model the aggregated cash flows based upon average maturities, coupons, options, and other features. In response to an ANPR question about how OFHEO should simulate gains and losses on derivative activities, Freddie Mac suggested that the underlying instruments should be modeled. Likewise, Freddie Mac's discussion of liabilities in its comments assumes that most liability instruments will be modeled individually. The only other comment was ACB's suggestion regarding accounting for the risk of counterparty default. ACB's recommendation that the stress test ''haircut'' (meaning reduce by a percentage) derivative positions when they were ''in the money'' (meaning the derivatives have a net positive value to the Enterprises) would require modeling cash flows of derivatives individually.

The issue of modeling liabilities and derivatives on an aggregated versus instrument level usually requires a trade-off between accuracy, model complexity, and information system resources. In most cases, the model for generating cash flows uses the same types of information for an individual instrument as it would for a group of similar instruments. For this reason, OFHEO's information system resources are capable of processing the large number of individual liabilities and derivatives in a reasonable amount of time. Therefore, OFHEO proposes to model the cash flows of all existing types of liabilities and derivatives individually, except certain instruments that have terms or risk characteristics based on a foreign currency, which are discussed below as a separate issue.

As with most other liabilities, the stress test will model GICs individually. However, given the variety of their terms and purposes, it was necessary to simplify the cash flow model for these instruments. The stress test models each GIC as if it pays out its specified interest on the starting balance amount over the entire stress period, unless the GIC includes an explicit maturity date. In the latter case, the stress test pays interest only until the maturity date, at which point it pays out the total principal.

2. Foreign Currency Linked or Unusual Instruments

The second liabilities-related issue arises because, from time to time, the Enterprises issue foreign currency-denominated debt and structured notes that are linked to a foreign currency. As discussed above, the Enterprises currently hedge all foreign currency-linked securities with derivatives or other financial instruments, resulting in synthetic securities denominated in U.S. dollars. Freddie Mac, the only ANPR commenter to address this issue, recommends modeling foreign currency-linked transactions differently from other instruments, explaining that ''hedge cash flows or the netted cash flows need to be calculated * * *.''

OFHEO agrees that currency-linked securities and the associated hedging instruments are different from other types of liabilities and derivatives of the Enterprises in that the cash flows of the individual instruments are linked to changes in currency values. OFHEO also recognizes that, in current practice, the Enterprises issue a limited volume of currency-linked instruments and

transfer all currency risk to third parties by hedging instruments. Further, with the exception of debt linked to foreign currency, the Enterprises have not issued liability instruments that were linked to indices or values (such as commodities or stock prices) that are not projected in the stress test.[168]

OFHEO concurs with Freddie Mac's comments that where all the currency risk is hedged, by swapping the foreign currency payments into dollars, the stress test could calculate the cash flows by creating a single synthetic liability, denominated in dollars and paying the net amount due under the related transactions. The stress test, therefore, applies that approach to instruments that are fully hedged. However, in the event that OFHEO finds that the foreign currency risk on any liability or derivative instrument has not been transferred fully to a third party, the stress test models the cash flow on such instruments as follows.

The stress test creates significant losses in unhedged currency positions in both the up-rate and down-rate scenarios. In the up-rate scenario, the stress test applies an exchange rate that increases the value of the foreign currency against the dollar by the same percentage that interest rates increase. For example, if the ten-year CMT shifts up by 50 percent, then the foreign currency value is shifted up by 50 percent against the dollar for the up-rate scenario.[169] The effect in this example would be that the Enterprise would be paying 50 percent more dollars due to the unhedged exchange rate shift.

A different adjustment is applied in the down-rate scenario. In that case, the stress test decreases the exchange rate of the dollar proportionately with the decline in the ten-year CMT, creating a decrease in the value of the dollar similar to that in the up-rate scenario. Thus, a downward shift in the ten-year CMT of 50 percent would be associated with a shift down of 50 percent in the exchange rate of the dollar. The effect in this example is that the Enterprise would be paying twice as many dollars due to the unhedged exchange rate shift.

This approach is simple, conservative and reasonable. The stress test recognizes that there can be substantial risk associated with unhedged positions in foreign currencies or other indexes or values to which instruments can be linked, but that it would be impractical for OFHEO to develop indexes for foreign currencies and all other values to which liabilities or derivatives could be linked. The exchange rate in the up-rate scenario is not based upon a model or an economic prediction, but does reflect a recognition that there have been occasions in the past where the dollar has declined in value as CMT rates have been increasing. Likewise, the dollar has also declined at times when CMT rates have decreased. Therefore, it is appropriate in a stress test to assume that the dollar moves in an unfavorable direction in both scenarios, to avoid creating a windfall to the Enterprises and to ensure significant financial stress in both scenarios. Moreover, OFHEO does not anticipate at this time that the Enterprises will be issuing foreign currency or unusual debt derivatives without using appropriate and complete hedges. If the Enterprises do alter their current businesses to enter into such debt, OFHEO will consider at that time whether a different treatment for the instruments involved is appropriate.

3. Call and Cancellation Options

An Enterprise will retire an outstanding issue of callable debt in order to issue new debt at favorable rates. For similar reasons an Enterprise may cancel a swap. For example, an Enterprise can cancel a pay-fixed/receive-floating swap—which, together with discount notes, creates a synthetic fixed-rate liability—in order to enter into a new swap that lowers the effective cost of the synthetic liability. OFHEO recognizes that, in general, an Enterprise will exercise its option when the net interest cost savings on a replacement security or contract, exceeds some threshold.

OFHEO received several comments to the ANPR that emphasized the importance of modeling the exercise of the call option. OFHEO concurs with these comments and, accordingly, treats callable debt in a manner that takes into consideration the exercise of the call option. OFHEO considered developing a financial model to value call and cancellation options and determine when they would be exercised in the stress test. However, the added precision of such a valuation model, as opposed to a simpler approach, would not have a significant effect on the capital requirement because the severe nature of the interest rate shocks included in the stress test result in either all eligible debt being called in a short period of time or no debt being called over the entire period. In addition, a valuation model would add a considerable amount of complexity to the cash flow model. Therefore, OFHEO sought to develop an alternative approach for decisions to exercise call and cancellation options that would provide a reasonable approximation of the Enterprises' procedures for exercising such options without increasing the complexity of the model.

OFHEO proposes to use, as a proxy for this threshold option value, the spread between the coupon rate of an outstanding actual or synthetic debt security and the Enterprise cost of funds for a new replacement security (the call-spread). Thus, in the stress test, the call option is exercised and the debt retired when the cost of the new debt plus the call-spread is less than the cost of the existing debt instrument. This methodology is often used as a simplified approach in modeling applications and was suggested by Freddie Mac in its comments to the ANPR. No other commenter suggested a specific approach.

To calculate an appropriate call spread, OFHEO received data from the Enterprises on the threshold value of call options on debt, in terms of a call-spread, over a range of reasonable times to maturity and valuation model parameter settings. After reviewing this information, OFHEO proposes to use a call-spread in the stress test of 50 basis points over the cost of issuing new bullet debt with the same time to maturity as the callable debt. This call-spread provides a reasonable debt call rule, without adding a considerable amount of complexity to the model.

4. Counterparty Risk

The ANPR sought comment about how, if at all, OFHEO should incorporate the effect of derivative counterparty defaults into the stress test. The Enterprises frequently enter into derivative contracts that, combined with various types of debt instruments (including structured notes), create synthetic liabilities at lower cost then actual debt with the same characteristics. Other derivative contracts are used as macro hedges against portfolio level risks. However, all swaps expose an Enterprise to counterparty credit risk, which is the risk that the counterparty may default on its contractual obligation at a time when the derivative contract has a positive market value to the Enterprise.

Currently, the Enterprises limit their exposure to counterparties by entering into swap transactions only with counterparties rated investment grade

[168] However, wherever the terms ''foreign currency'' or ''currency'' are used, they should be read to include any unit or value, except those interest rate indices that are included in the stress test, in which debt or derivatives may be denominated or to which such instruments may be linked.

[169] Shifting the value of the other currency up 50 percent has effect of decreasing the value of the dollar against that currency by ⅓. In other words, one could buy the same amount of dollars with only ⅔ the amount of other currency.

and by requiring all counterparties to execute collateral pledge agreements. These pledge agreements require any counterparty currently rated or subsequently downgraded to a less than a AAA credit rating to post collateral to the extent that net losses on its contracts [170] with an Enterprise exceed threshold levels. The threshold levels vary based on the counterparty's rating. The Enterprises do not require AAA-rated counterparties to post collateral, but if any counterparty is downgraded, the collateral pledge agreements subjects it to the more stringent collateral requirements of its new lower rating. Freddie Mac, in its comments, describes additional measures it uses to mitigate counterparty risk, which include using contracts with close-out and netting arrangements that allow Freddie Mac to offset losses on one contract with a particular party against gains on another contract. Freddie Mac also described its practice of requiring guarantees from well-capitalized parent companies and of periodically marking each contract to market at full replacement value.

In commenting on the ANPR, Freddie Mac stated that its management of credit risk on derivatives is such that the stress test should specify no losses due to counterparty default. Freddie Mac suggested that any losses would be covered adequately by the 30 percent add-on that the 1992 Act requires for management and operations risk and by the minimum capital standard. ACB, commenting generally on the subject of counterparty risk, stated that where collateral is provided, the risk of counterparty failure is remote. ACB suggested that, at most, a straightforward ''haircut'' on ''in the money'' derivative positions should be applied.

After consideration of these comments, OFHEO determined that reducing the haircuts for derivative counterparty risk by 80 percent from haircuts on other types of third party credit risk would provide appropriate recognition for Enterprise collateral agreements. However, OFHEO did not agree with Freddie Mac that the stress test should apply no haircuts. There always remains the possibility that counterparties could default on their obligations due to a sudden calamity that could prevent collateral from being posted. Also, collateral values can decline over time or collateral may be subject to competing claims. Sudden business bankruptcies and decline or impairment of collateral value would be even more likely than usual under the harsh economic circumstances of the stress test. Accordingly, and for the same reasons that similar haircuts are applied to mortgage credit enhancements and non-mortgage investments, OFHEO proposes to specify losses in the stress test due to failure of derivative counterparties.

OFHEO proposes to take into account the amount of loss due to derivative counterparty default as follows. As illustrated in Table 29, the stress test applies haircuts that increase linearly (by equal amounts) each month to the net payments from derivatives with a given counterparty over the term of the contracts with that counterparty. That is, if the Enterprise's net swap position across all contracts with a particular counterparty imply cash payment to the Enterprise during a given month, that cash payment is reduced (''haircut'') by an amount determined by the public credit rating of the counterparty and period in which the payment is owed. The calculation is performed for each counterparty and for each month in which a counterparty has swap agreements with the Enterprise. The cash flows for all derivatives with each counterparty are netted, except swaps that exchange into U.S. dollars any currency in which Enterprise debt may be denominated. Haircuts are applied separately to these derivatives, as explained below.

Table 28. Haircuts To Income From Derivatives

Month	AAA	AA	A	BBB
12	.2%	.4%	.8%	1.6%
24	.4%	.8%	1.6%	3.2%
36	.6%	1.2%	2.4%	4.8%
48	.8%	1.6%	3.2%	6.4%
60	1.0%	2.0%	4.0%	8.0%
72	1.2%	2.4%	4.8%	9.6%
84	1.4%	2.8%	5.6%	11.2%
96	1.6%	3.2%	6.4%	12.8%
108	1.8%	3.6%	7.2%	14.4%
120	2.0%	4.0%	8.0%	16.0%

The haircuts reflect the probability that some counterparties will be unable to meet their obligations during the stress period. Haircuts become progressively larger as the counterparty rating decreases, with parties rated BBB

[170] These losses are calculated on a mark-to-market basis, because most derivatives involve features, such as payment streams and options, the values of which fluctuate with changes in the yield curve.

or lower and unrated parties receiving the most severe haircut. The haircut for each rating category is cumulative rather than additive. It increases linearly for each month of the stress period, beginning in the first month of the stress test until the full amount of the discount is reached in the 120th month. Table 29 reflects the size of the haircut at the end of each 12 month period during the stress test. Rating downgrades are not modeled. Instead, deterioration in the financial condition of counterparties due to the stressful environment is reflected in the linear increase of the haircuts.

The proposed approach recognizes that both Enterprises utilize netting and close out arrangements such as those described by Freddie Mac in its comments. If OFHEO determines that not all derivatives with a particular counterparty are covered by a single arrangement, the derivatives' cash flows will not all be netted together. Instead, the stress test will group the derivatives by netting agreement and apply haircuts separately to the net cash flow for the derivatives covered by each agreement. For derivatives covered by no netting agreement, the haircut would be applied on an instrument by instrument basis to any derivatives that are ''in the money.'' In the event that any derivatives contracts do not include standard Enterprise collateral agreements, the haircut percentages imposed will be those in Table 27 in section III.C., Mortgage Credit Enhancements.

As mentioned above, the stress test will apply haircuts separately to swap agreements that exchange into U.S. dollars any other currency in which Enterprise debt may be denominated. Because these agreements entail the Enterprise receiving payment denominated in other currencies, which the stress test does not model, the stress test cannot net them against more usual interest rate swaps. Neither can the stress test net these agreements against each other, since they use variety of currencies. Therefore, the stress test applies haircuts to each individual contract. Because the collateral agreements and investment ratings do not differ for the counterparties to these agreements, the stress test applies the same counterparty haircut percentages to them as it does for interest rate swaps. However, the haircut is applied to the 'pay' side of these contracts rather than to the 'receive' side. The effect will be a loss on each swap transaction equal to the haircut amount. This approach recognizes that the Enterprises use these swap agreements only to match a debt position for which the swap agreement is a hedge.

E. Non-Mortgage Investments

In addition to mortgage investments, the Enterprises hold non-mortgage investments [171] that include Treasury securities, federal funds, time deposits, Eurodollar deposits, asset-backed securities [172] (ABS), corporate securities, and state and municipal bonds.[173] As of December 31, 1997, non-mortgage investments at Fannie Mae constituted about $66.8 billion (17 percent of on-balance sheet assets) and $13.8 billion (7.0 percent) at Freddie Mac.

OFHEO considered several issues related to how the stress test should model the cash flows associated with the Enterprises' non-mortgage investments. The first issue concerns whether the stress test should model cash flows from such investments at the instrument level or at an aggregated level. Such aggregation entails grouping individual instruments with similar terms and risk characteristics and modeling the group as a single instrument. The proposed stress test models the cash flows of all non-mortgage investments on an instrument-by-instrument basis. Evaluating whether to model non-mortgage investments on an instrument versus an aggregated level represents a trade-off between accuracy, model complexity, and information system resources. Instrument level modeling provides greater accuracy than modeling aggregated investments because aggregating instruments may result in losing information. On the other hand, instrument level modeling may result in added complexity and require additional information system resources. Neither of these concerns poses a significant constraint in the case of modeling the Enterprises non-mortgage investments. Accordingly, OFHEO believes that modeling cash flows from non-mortgage investments is practicable and appropriate. With respect to complexity, the model for generating cash flows uses the same types of information for an individual instrument as it would for a synthetic instrument representing a group of actual instruments. With respect to information resources, OFHEO systems are capable of processing the large number of individual investments in a reasonable amount of time.

The second issue concerns whether there should be any simplifying assumptions in modeling the cash flows associated with non-mortgage investments. OFHEO has decided to include the following three simplifying assumptions which will facilitate this modeling, without having a significant effect on the risk-based capital requirement. First, for investments with common characteristics, the stress test specifies one payment frequency for those instruments. Second, the stress test standardizes prepayment speeds for ABS, i.e., how fast principal (both scheduled principal and prepayments) is returned. Third, the stress test will not apply different ABS prepayment speeds in different interest rate environments, because ABS typically pay off quickly and therefore are not significantly affected by interest rates. In addition, the effect of specifying different prepayment speeds on the risk-based capital requirement would not be significant, and would add unreasonable additional complexity to the stress test.

OFHEO next considered whether the proposed stress test should, with respect to non-mortgage investments, model their credit risk, i.e., the risk that there will be a default on an instrument. OFHEO has determined that it is appropriate to model such credit risk because some issuers would be unable to meet their obligations during the stress period. The proposed stress test ties the credit quality of non-mortgage investments to the credit rating specified by one or more nationally recognized public rating organizations, such as S&P or Moody's. While public offerings usually have a single rating, they occasionally have split ratings. In the case of split ratings, the stress test will use the lowest rating.

The stress test first generates cash flows for a given instrument and then reduces those cash flows by a specified percentage (i.e., ''haircut'') based on the public rating organization. The percentage haircut increases as the rating decreases so that a highly-rated instrument will have a lower haircut than a lower rated instrument. In the absence of a rating, the stress test would apply the lowest rating category. The haircuts increase linearly (i.e., in equal increments) during each month of the

[171] Both OFHEO and HUD are authorized to regulate the Enterprises' non-mortgage investment activities. OFHEO has specific authority to ensure that the Enterprises are adequately capitalized and operating safely (1992 Act, section 1313 (12 U.S.C. 4513)), and HUD has general regulatory authority over the Enterprises to ensure that the purposes of the 1992 Act are accomplished (1992 Act, section 1321 (12 U.S.C. 4541)). While HUD's current regulations do not contain specific provisions about the Enterprises' non-mortgage investments, HUD issued an advance notice of proposed rulemaking (ANPR) seeking comment about the need for it to regulate such investments. (62 FR 68060, December 30, 1997)

[172] ABS are similar to MBS but are backed by nonmortgage assets, such as receivables on car loans and credit cards.

[173] Although they are generally tax-exempt, for purposes of the stress test, mortgage revenue bonds (MRBs) are not included in the category State and municipal bonds. MRBs are discussed in the section titled ''other housing assets.''

stress period. Table 29 illustrates the ending haircuts in the 120th month for each rating category. Refer to section III. C., Mortgage Credit Enhancements for the discussion of the proposed haircuts.

Table 29. Rating and Stress Period Ending Haircuts

Rating Category	AAA	AA	A	BBB
All counterparties and securities except derivative counterparties	10%	20%	40%	80%

An instrument that is unrated or has a rating that is below investment grade will receive the most severe haircut. This reflects OFHEO's determination that it is appropriate for the stress test to reflect high credit losses for non-mortgage investments that are more risky than the instruments that are now included in the Enterprises' current holdings. The Enterprises' non-mortgage investments are currently of high quality,[174] but the Enterprises are not statutorily or otherwise legally required to invest solely in high quality instruments. It is possible that an Enterprise might change its investment practices to include non-mortgage investments with lower credit quality.

F. Other Housing Assets

Other housing assets are a small category of Enterprise assets that need to be modeled differently than retained whole loans and mortgage-backed securities are modeled. They are primarily mortgage revenue bonds (MRBs). They also include certain Real Estate Mortgage Investment Conduits (REMIC) securities issued by private entities and some interests in partnerships and joint ventures. These assets have cash flow characteristics that vary from investment to investment, and the data required to model cash flows precisely is not readily available. The impact of how these assets are modeled on the stress test results will be modest.

1. Mortgage Revenue Bonds

Mortgage revenue bonds are issued by state and local housing authorities to raise funds for single family and multifamily mortgage lending programs. Both single and multifamily mortgage revenue bonds are secured by mortgage loans, reserve funds, and other credit enhancements. Government subsidies to some multifamily projects also provide implicit credit support. Most MRBs are tax exempt. The Enterprises are permitted to hold up to two percent of their assets in tax exempt securities.

OFHEO considered whether to model MRB cash flows on individually or on an aggregated basis. The stress test models MRB cash flows bond-by-bond. Although one modeling approach is to group securities and use weighted average interest rates and terms to calculate future cash flows, OFHEO determined that calculating cash flows individually is simpler. Available computer hardware and software allow the calculation of cash flows on many individual securities in almost the same amount of time it takes to calculate a single cash flow using average rates and maturities for a group. In addition, any decrease in precision that might be introduced through pooling is avoided.

OFHEO next considered whether to calculate interest and principal payments for the MRBs based on each security's actual structure or to use a proxy for calculating bond payments. Interest on MRBs is paid at the bond rate on the principal amount of the bond, but MRBs have different schedules for principal repayment. In some MRBs, the issuer may use principal repayments from mortgages associated with one MRB transaction to retire bonds from another transaction. In many transactions, issuers have substantial discretion to retire bonds early. There is no single source of information on MRB structures, nor is the information readily available from multiple sources.

OFHEO determined that the modeling approach used to calculate cash flows on Ginnie Mae securities would provide a reasonable proxy for cash flows on mortgage revenue bonds. Specifically, the bonds are modeled as passthrough securities, with the underlying mortgage collateral bearing a coupon 75 basis points higher than the bond coupon. Although MRB payments are not passthroughs of mortgage loan payments, the MRB payments are related to the mortgage payments. MRB payments and Ginnie Mae security payments would be affected similarly by loan terminations and by economic conditions. Further, borrowers benefiting from MRB programs are similar to borrowers for the FHA and VA loans that collateralize Ginnie Mae securities, and the loan characteristics are similar. Therefore, the stress test calculates cash flows for MRBs essentially the same way that it calculates cash flows for Ginnie Mae securities. It amortizes the bond principal using loan termination rates for FHA and VA loans that have the maturity of the MRB and coupons equal to the MRB coupon plus a spread.

OFHEO considered whether to design a modeling approach specifically for multifamily MRBs or to model cash flows for single family and multifamily MRBs the same way. The stress test models cash flows for multifamily MRBs as though they were single family Ginnie Mae securities, just as it does for single family MRBs.

Modeling multifamily MRB cash flows according to the structures of the securities is hampered by the same data problems that affect modeling single family MRB cash flows. Therefore, the stress test needs to use a proxy. The choice of proxy is limited. Information on Government-insured multifamily loans is not readily available. Enterprise multifamily MBSs are not an acceptable proxy for multifamily MRBs, because the Enterprises' multifamily loans differ from the loans that collateralize multifamily MRBs, and multifamily MBSs pay differently from multifamily MRBs. Because multifamily MRBs are a very small percentage of each Enterprise's assets and their impact on risk-based capital is minimal, OFHEO determined that single family Ginnie Mae securities would be used as a proxy for multifamily MRBs.

The stress test addresses the credit risk associated with MRBs by applying the haircuts that are tied to the public credit ratings of the bonds. The haircuts will be in the same amount and will be applied in the same way as haircuts for

[174] For instance, in response to HUD's ANPR, Fannie Mae commented that ''Nearly two-thirds of the [liquid investment] portfolio is rated AAA (or the equivalent), and nearly all (98 percent) of the portfolio is rated at least A (or the equivalent).

credit enhancements and non-mortgage investments. Currently, a sizeable majority of the MRBs held by the Enterprises are rated AA and above.

2. Private Label REMICs

The Enterprises own a small amount of REMIC securities that are issued by private sector entities. For most of these securities, the information that would be necessary to calculate cash flows for the REMIC collateral and thus for the REMIC securities is not readily available.

As with mortgage revenue bonds, OFHEO considered whether to model the cash flows of the REMIC securities or to model cash flows using a proxy. The stress test uses a proxy. The stress test models cash flows for private REMIC securities using the same modeling approach as it uses for MRBs. The stress test amortizes the principal of the REMIC securities using the appropriate termination rates for the coupons and maturities.

Data that is needed to project precise cash flows is not readily available. The costs of developing the data and reverse engineering the REMIC securities are not warranted by any incremental refinement that might result. Most of the REMIC securities held by the Enterprises are rated AAA. The credit risk of the private issue REMICs will be taken into account by applying the same haircuts as those used for MRBs.

3. Interests in Partnerships and Joint Ventures

OFHEO decided not to model gains or losses on interests in partnerships or joint ventures, a category that totals less than $200 million, or less than 0.03 percent of Enterprise assets. These assets carry little credit risk but generate tax losses that benefit the Enterprises. OFHEO has determined that projecting cash flows and tax benefits of these assets would create significant additional complexity in the stress test, without having any material impact upon the risk-based capital requirements. Accordingly, the stress test treats these assets as though they remain on the balance sheet with no run-off and no associated income. In the future, if these investments become a larger proportion of either Enterprise's book of business, OFHEO will reconsider how they are modeled in the stress test.

G. Commitments

The 1992 Act specifies that during the stress period the Enterprises will purchase no additional mortgages nor issue any MBS, except that—

> [a]ny contractual commitments of the enterprise to purchase mortgages or issue securities will be fulfilled. The characteristics of resulting mortgage purchases, securities issued, and other financing will be consistent with the contractual terms of such commitments, recent experience, and the economic characteristics of the stress period.[175]

The term ''contractual commitments'' generally refers to binding agreements that the Enterprises enter into with seller/servicers to purchase mortgages or to swap mortgages for MBS. The term also refers to agreements to sell such securities to investors. The total of outstanding purchase or swap commitments at both Enterprises at any point in time is generally in the tens of billions of dollars. The following discussion describes the issues faced by OFHEO in determining the appropriate volume and characteristics of mortgages delivered under commitments.

1. Definition of the Term ''Commitment''

The proposed risk-based capital regulation incorporates, by reference, the definition of ''commitment'' from OFHEO's minimum capital regulation. OFHEO defines ''commitment'' in the minimum capital regulation as follows:

> Commitment means any contractual, legally binding agreement that obligates an Enterprise to purchase or to securitize mortgages.[176]

This definition includes ''mandatory'' and ''optional'' commitments. Mandatory commitments bind the seller to deliver, and the Enterprise to accept, a certain volume of mortgages. Optional commitments are delivery contracts that commit the Enterprises to purchase or swap a specified volume of loans, but do not commit the seller to deliver any loans. The definition includes commitments that do not specify fixed prices or volume, but otherwise legally bind an Enterprise.

Freddie Mac, the only ANPR commenter to address the definition of commitments, recommended that contractual commitments be defined to include only agreements that legally bind the Enterprises to purchase mortgages. According to Freddie Mac, ''[u]nder fundamental contract law, an agreement is only binding if all of its key terms are included and agreed upon.'' Freddie Mac further stated that price and volume are two key terms and that only commitments containing this information are legally binding contracts for the Enterprises. This comment suggests that OFHEO should not model commitment contracts that do not contain price and volume information (e.g., master commitments for cash purchases).

OFHEO has found no reason to adopt a different definition for purposes of computing risk-based capital from that used for computing minimum capital. In both cases, the term should mean any legally binding agreement that obligates an Enterprise to purchase or securitize mortgages. OFHEO does not believe it necessary or appropriate to restrict the definition of the term ''commitment'' by reference to price, volume, and fees, because agreements may be legally binding even when they lack specificity on all terms.[177] It would add unnecessary complexity to attempt to reflect the myriad details of diverse State contract laws in the regulatory definition. Moreover, to do so would be inadvisable in light of Congress' specific concerns regarding the need for capital to support commitments and other off-balance-sheet obligations. For example, in discussing the need for the capital requirements of the 1992 Act, Congress expressed the concern that the risk in off-balance-sheet obligations had not been captured under prior capital standards:

> The capital provisions of the GSEs' charter Acts limit their debt to 15 times their capital unless HUD sets a higher ratio * * * This is unsatisfactory because no capital need be held against the GSEs' $750 billion of off balance sheet guarantees * * *[178]

Recognizing this concern, it would be inappropriate for OFHEO to promulgate a narrow definition that could exempt certain legally binding commitments from the risk-based capital requirement.

Freddie Mac also recommended a definition of commitments that excludes all optional commitments, including those containing price and volume information. Specifically, Freddie Mac suggested the following definition:

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[175] 1992 Act, section 1361(a)(3)(A) (12 U.S.C. 4611(a)(3)(A)). The 1992 Act does provide for later amendment of the rule to address new business during the stress period, but not until after this regulation is final. The 1992 Act requires that, within one year after this regulation is issued, the Director of the Congressional Budget Office and the Comptroller General of the United States shall each submit to the Congress a study of the advisability and appropriate form of any new business assumptions to be incorporated in the stress test. Section 1361(a)(3)(C) (12 U.S.C. 4611(a)(3)(C)). Subparagraph 1361(a)(3)(B) (12 U.S.C. 4611(a)(3)(B) authorizes the Director to consider these studies and make certain new business assumptions. However, that subparagraph does not become effective until four years after this regulation is issued.

[176] 12 CFR 1750.2; *See* 61 FR 35610, July 8, 1996 (explanation of definition).

[177] *See* Restatement (Second) of Contracts § 204 (1981).

[178] S. Rep. No. 102–282, at 11 (1992) (referring to the existing capital standard, which the 1992 Act repealed).

Contractual commitment means an obligation of an Enterprise that legally binds the Enterprise to issue securities or purchase mortgages and *legally binds a third party* to purchase securities or deliver mortgages, and that sets forth all terms of the transactions including price, volume, and fees.

(emphasis added).

The phrase ''legally binds a third party'' would define a commitment to include only an agreement that binds the counterparty to deliver mortgages or to purchase securities, thus excluding optional commitment contracts.

OFHEO disagrees with this comment and includes optional commitments in the stress test definition. The 1992 Act is clear on this issue, because it refers to ''commitments of the *enterprise* to purchase * * * or issue'' (emphasis added) but includes no requirement that the commitment bind others to deliver mortgages. Optional commitments obligate the Enterprise to purchase and are optional only for the seller. Therefore, optional commitments fall squarely within the statutory definition.

2. Retained vs. Securitized Mortgages

The proposed regulation specifies that all loans delivered under commitments are packaged into securities (securitized) and sold. This specification avoids requiring OFHEO to predict business decisions by the Enterprises that are highly judgmental and impossible to predict accurately. OFHEO recognizes that in practice the Enterprises make day-to-day decisions to sell or retain loans. However, the simple rule proposed by OFHEO avoids the complexity of attempting to model such business decisions.

ACB commented that ''[a]ny loans not presold by the GSEs should be assumed to be retained in portfolio and carry both the credit and IRR [interest rate risk] exposure.'' OFHEO disagrees with ACB's suggestion, because it would add undue complexity to the stress test. At no time are the Enterprises obligated by the terms of a commitment to retain mortgages in portfolio. Furthermore, retaining these mortgages in portfolio in the stress test would require OFHEO to predict how the Enterprises would finance and hedge the interest rate risk associated with the purchases. These predictions would increase greatly the complexity of the stress test and introduce assumptions about future Enterprise management, which OFHEO, as a general rule, has found inappropriate in a ''no new business'' stress test.

For these reasons, OFHEO determined that proposing that all loans delivered under commitments will be securitized and sold is a reasonable, straightforward approach.

3. Modeling Delivery Percentages

The stress test will provide that, in the down-rate scenario, 100 percent of all loans that the Enterprises are obligated to accept will be delivered and, in the up-rate scenario, 75 percent of those loans will be delivered. As explained below, OFHEO considered the relevant comments on this issue and found the proposed rule to be a reasonable and practical method of estimating the volume of new mortgages that will be delivered in the stress test.

In determining the appropriate percentage, OFHEO looked first to the 1992 Act, which provides that commitments will be ''fulfilled.'' In contractual parlance this term means that the parties will fulfill their contractual obligations under these instruments. Therefore, OFHEO decided to propose a simple rule, based upon estimates of the delivery volumes that would be likely to occur if both parties fulfill those obligations.

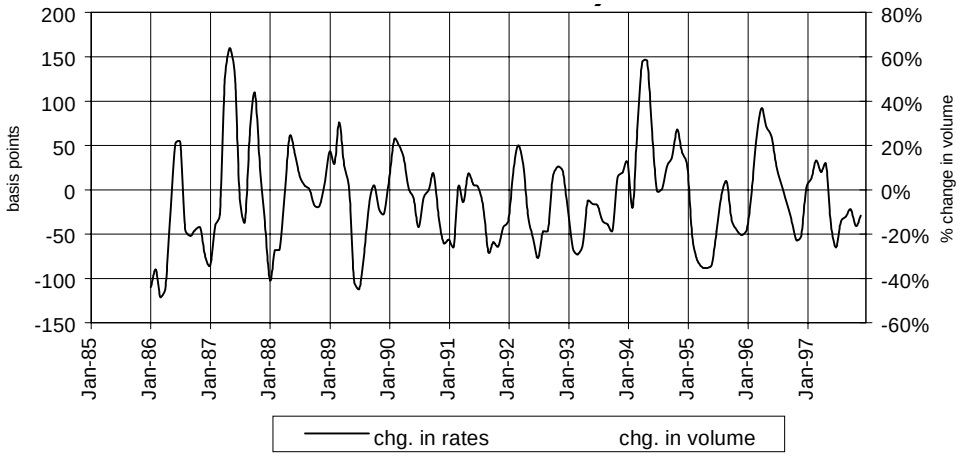
Not all mortgages that the Enterprises are obligated to accept under commitments are actually delivered. Optional commitments obligate the Enterprise to purchase up to a specified dollar amount of mortgages, but do not obligate sellers to deliver any mortgages. They can be fulfilled by both parties even though fewer than all the loans specified in the commitment are delivered. Under a mandatory commitment, the Enterprise is also obligated to purchase a specified dollar value of loans, but the seller fulfills the contract either by delivering the specified volume of loans or by paying a ''pair-off'' fee specified in the commitment agreement. These fees are a form of liquidated damages that, under the terms of mandatory commitments, are payable by sellers who fail to deliver the full amount of mortgages specified in the commitments. Therefore, under either type of commitment, less than all the stated mortgage volume may be delivered.

As mentioned above, the proposed regulation specifies that, in the down-rate scenario of the stress test, 100 percent of loans the Enterprises are obligated to buy or securitize will be delivered under all types of commitments. In the up-rate scenario, 75 percent of those loans will be delivered. This specification reflects the fact that when interest rates decline significantly, the volume of new purchase mortgages and mortgage refinancings generally increases. Therefore, in the down-rate scenario, lenders should have plenty of mortgage volume to meet or fill all commitments. In contrast, when interest rates rise significantly, the demand for mortgages tends to fall. Therefore, in the up-rate scenario, sellers would find it difficult to generate enough mortgages to meet outstanding commitments. Because the proposed regulation provides that all loan deliveries will be made in the first three to six months of the stress period (see section III.G.4., Delivery Timing below), those deliveries are particularly sensitive to short-term changes in interest rates. Thus, the steeply rising rates in the first few months of the up-rate scenario have a significant impact upon delivery percentages. It would be inappropriate, however, to assume that loan deliveries would decline more than 25 percent, given that many of the commitments are mandatory and that existing home purchase contracts will require financing. Lenders will also have a certain volume of outstanding loan commitments with locked rates, most of which would close.

Figure 3 below shows that, during the most recent increase in rates of any significance (the first half of 1994), a three month increase in interest rates of 150 basis points led to a drop in market origination volume of roughly 30 percent. Also, during the 12-year period shown, market volumes never decreased over any three-month period by more than 25 to 30 percent. Because the stress test will include rate changes of 150 basis points or less in the first quarter, the data led OFHEO to conclude that a 75 percent delivery rate would be a reasonable specification for the up-rate scenario of the stress test.

The proposed regulation does not credit the Enterprises with income from ''pair-off fees'' in the up-rate environment for two reasons. First, there is no usable data on the payment of these fees or on the percentage of deliveries under commitments. Therefore, attempting to model these fees would require estimating, with no supporting data, the percentages of loans to be delivered under mandatory, as opposed to optional, commitments. Second, the fees are not always charged by the Enterprises. Therefore, including the fees would require OFHEO to speculate how frequently or under what circumstances the Enterprises would impose them.

Figure 3. Change in Rates vs. Change in Volumes (over 3 months)



In its ANPR comments regarding delivery percentages, Freddie Mac recommended that OFHEO develop an econometric model of delivery percentages for commitments. This model would be based on recent prepayment experience of each Enterprise and the prepayment rates produced by OFHEO's default/prepayment model. The model that Freddie Mac recommended would compute commitment delivery percentages as follows:

1. OFHEO would determine a means of estimating the extent to which sellers would fulfill mortgage purchase commitments by (a) delivering mortgages or (b) paying a pair-off fee without delivering the mortgages.

2. Then, OFHEO would determine a stress period delivery percentage under all commitments to reflect the effect of stress period conditions. Specifically, Freddie Mac suggested that a good approximation of this effect would be the ratio of the sum of the prepayment rate and the purchase-growth rate (rate of increase or decrease in the volume of loans purchased by the Enterprises) during the relevant portion of the stress period to the sum of the prepayment rate and the purchase growth rate during a recent period immediately prior to the stress period. This ratio would be multiplied by a ''baseline'' delivery percentage, which is the normal delivery percentage during times of little interest rate fluctuation. Under this approach, the stress test delivery percentage would be expressed as follows:

$$\text{Delivery \%} = \frac{(\text{ppmt. rates during stress pd.}) + \text{growth rate during stress pd.} \times \text{base-line delivery \%}}{\text{recent ppmt. rates} + \text{recent growth rate}}$$

The stress period growth rate would be zero until such time as OFHEO included new business assumptions in the stress test, and the stress period delivery percentage would not be allowed to exceed 100 percent.

Freddie Mac bases its approach on two assumptions. First, the volume of outstanding commitments at the beginning of the stress period (i.e., the then current volume of outstanding commitments) is assumed to be related to the volume of mortgage purchases that the Enterprises and sellers anticipated at the time they entered into the commitments. Second, the sellers' actual rate of deliveries during the stress period under outstanding commitments is assumed to be closely related to actual mortgage purchase activity during the relevant portion of the stress period.

OFHEO agrees with these assumptions and used them to determine appropriate stress test delivery percentages. OFHEO also agrees that an econometric approach such as that proposed by Freddie Mac might provide a relatively sophisticated representation of what would actually occur under stress test conditions. However, there are insufficient data to construct such a model of commitments at this time. Historical data available to OFHEO do not reveal what percentages of commitments have been delivered. The Enterprises have provided descriptions of commitment types and made statements about their general business practices and the length of and delivery patterns of commitments. However, OFHEO has found available data are inadequate to associate actual mortgage purchases with commitments. Therefore, neither of the two steps in the Freddie Mac proposal currently is possible. There is no source of data to determine a reasonable estimate of pair-off fee payments or to determine a historical baseline delivery percentage.

ACB's ANPR comments suggested that a historically based dropout factor be applied to account for failure to ''make/take delivery by counterparties.'' The lack of historical data regarding actual delivery percentages under commitments limits the accuracy with which such a factor or factors can be calculated. However, OFHEO proposes an approach consistent with the ACB comment. The stress test specifies fixed delivery percentages for commitments in the down-rate and the up-rate scenarios. These percentages are based on historical information, displayed in Figure 3, about mortgage volume in the entire mortgage market during periods when rates have risen and fallen sharply. This information demonstrates that declining interest rates are generally accompanied by or followed shortly by increases in the volume of

the one-year CMT, along with the average margin for ARM loans originated within the past six months, to determine mortgage rates on newly delivered ARMs.

In its ANPR comments, Freddie Mac recommended two methods of modeling loan mix. Freddie Mac recommended that the loan mix of mortgages delivered under commitments could be the same as the loan mix of the Enterprises' outstanding portfolios. Alternatively, Freddie Mac suggested that OFHEO look to historical experience and base the stress period mix on the mix during past up-rate and down-rate environments. Freddie Mac further commented that the mix of mortgages delivered under outstanding commitments should not be modeled based on recent mortgage deliveries. Its rationale was that the capital requirement associated with commitments could vary dramatically because of one-time special purpose transactions. Freddie Mac cited, as an example, the distorting effects created by an Enterprise purchase of a large Cost Of Funds Index (COFI) ARM portfolio representing 30 percent of a quarter's purchases.

OFHEO did not adopt Freddie Mac's first suggestion because OFHEO believed that the mix of loans in an Enterprise's overall portfolio has only a limited relationship to the loans that will be delivered under current commitments. An Enterprise's portfolio at any given time contains loans obtained over many years during periods when economic conditions may have been quite different from the conditions that will exist at the start of the stress test. Current commitments, by contrast, are more likely to reflect Enterprise management's efforts to adjust the mix in its portfolio than they are to reflect the current mix in the portfolio. For these reasons, OFHEO found the current mix of loans at the Enterprises to be an unsatisfactory proxy for the mix of loans to be delivered under current commitments.

Using a two-quarter (versus a one-quarter) period to compute the loan mix addresses Freddie Mac's concern over distortions created by occasional special purpose purchases. However, if large special purpose purchases of unusual mortgages occur frequently, it is appropriate that the stress test reflect some higher-than-usual risk by projecting continuing purchases of such mortgages.

OFHEO also examined Freddie Mac's suggested alternative methodology—basing the loan mix on the ''mix that prevailed'' during prior up-rate and down-rate scenarios. Given the lack of historical data regarding deliveries under commitments, there is no direct evidence of what the experience of those deliveries has been. At best, information might be inferred from data regarding total deliveries, either at the Enterprises or in the market as a whole. However, OFHEO's research has found that, although long term increases in interest rates produce more ARMs and long term decreases produce more FRMs, short term changes in interest rates have little discernable affect on the ratio of ARMs to FRMs that are delivered to the Enterprises.

For these reasons, OFHEO concluded that a more detailed and complex model based upon historical patterns of loan deliveries would be unlikely to improve the stress test's accuracy or sensitivity to risk or yield a significantly different result. OFHEO is confident that the proposed approach reflects a reasonable delivery mix for the stress test and that any fine-tuning that might result from a more complex model would have only an incremental effect. Also, because the proposed regulation specifies that these new loans will not be held in portfolio, they create little interest rate risk for the Enterprises. For all these reasons, OFHEO does not propose the type of detailed model of loan mix contemplated in Freddie Mac's comments.

ACB also commented on loan mix, explaining that the mix of commitments should be ''as of the actual reporting date, subject to adjustment for any demonstrable 'window dressing' practices by the GSEs.'' ACB assumed that data were available to determine what loan mix was specified under outstanding commitments at any point in time. As explained above, those data are not available. OFHEO interpreted ''window dressing,'' to mean attempts that an Enterprise might make to alter temporarily the loan mix in its commitments just prior to the beginning of a particular quarter. OFHEO believes that the proposed approach, which looks to the mix of loans actually delivered over the last two quarters, addresses ACB's concern that an Enterprise might engage in ''window dressing.''

6. ''No New Business'' Rule

World Savings commented in response to the ANPR that the stress test model should reflect ongoing business, not a wind down scenario. The comment stated that the assumption of no new business except for fulfillment of contractual commitments is ''fundamentally flawed,'' because it assumes the Enterprises will be prescient about the magnitude of the financial stress. World Savings commented that this assumption causes the test to underestimate the Enterprises' need for capital, because it causes their portfolios to shrink unrealistically. By contrast, a comment by Professor Yezer of George Washington University advocated placing limits on the size of the Enterprises' portfolios in the stress test. He concluded that ''one needs a model of [Enterprise] response to stress that makes sense in terms of modern financial theory of investment, not passive reaction to adverse changes as contemplated in the proposed rule.''

Both of these comments suggest an alternative approach to new business that cannot be addressed at this time because the approach in the regulation is mandated by section 1361(a)(3) of the 1992 Act.[180] That section requires that the initial risk-based capital regulation assume that the Enterprises take on no new business other than deliveries under existing commitments. After the issuance of the regulation, the 1992 Act requires studies by the Congressional Budget Office and the Comptroller General of the United States of the advisability and appropriate form of any new business assumptions to be incorporated in the regulation. Only after completion of those studies and their submission to the Congress may the Director, after considering them, propose amendments to the regulation that would incorporate new business assumptions during the stress period.[181]

H. New Debt and Investment Rules

During the stress period, an Enterprise invests and borrows, as needed, based on net cash flows. The stress test projects cash inflows and outflows for each month of the stress period. To the extent cash inflows exceed cash outflows in any month, the stress test must specify how an Enterprise employs the excess funds. Conversely, to the extent that cash outflows exceed cash inflows in any month, the stress test must specify how an Enterprise obtains the funds to cover the cash deficit.

The 1992 Act provides no specific guidance for new debt issuance or new investments during the stress test. OFHEO sought new debt and new investment rules that would alter as little as possible the credit and interest rate exposures of an Enterprise generated by its initial asset, liability, and derivative positions.

The proposed approach provides that all new debts and investments are short-

[180] 1992 Act, section 1361(a)(3) (12 U.S.C. 4611(a)(3)).

[181] 1992 Act, section 1361(a)(3)(B)–(D) (12 U.S.C. 4611(a)(3)(B)–(D)).

term instruments. More specifically, OFHEO proposes that the Enterprises fund all monthly net cash outflows during the stress test by issuing six-month discount notes. OFHEO also proposes that excess funds will be invested at the six-month Treasury bill rate in instruments that mature one month later.

1. Rationale for New Debt and New Investment Rules

The purpose of a ''no new business'' stress test is to subject an Enterprise's business at the beginning of the stress period to adverse conditions, without introducing during the stress period any business responses to deteriorating business conditions that would tend to increase or decrease risk. Consistent with this purpose, the proposed new debt and investment rules are designed to project the effects during the stress period of specific stressful circumstances on the Enterprises, given the risks embodied in their business positions at the start of the stress test, while minimizing the introduction of any new risks.

Accordingly, the stress test uses simple rules for the issuance of debt or the investment of liquidity. OFHEO intentionally does not propose to predict what asset-liability management decisions an Enterprise might make, predictions that would be difficult in any event.[182]

The hazards of predicting the response of financial institutions to stressful conditions are well illustrated by the behavior of the thrifts during their financial crisis in the 1980s. While some institutions sought to limit or reduce their risks in that difficult environment, others made choices that greatly increased risk, in effect gambling that a fortunate turn of events would be their best chance of financial salvation. These choices largely determined the fate of the institutions. Similarly, incorporating activities that project the Enterprises's responses to the duration or severity of economic conditions during the early part of the stress period, while these conditions are deteriorating rapidly, could profoundly affect the Enterprises' financial performance in the stress period.

For these reasons, the stress test makes no provision for an Enterprise to rebalance its portfolio as its asset and liability positions evolve during the stress test. The Enterprises are exposed to interest rate risk principally because changes in interest rates cause changes in the market (and economic) values of their long-term, fixed-rate assets and liabilities, and of their derivative contracts. These changes in value are reflected in subsequent accounting statements of earnings and net worth.

If an Enterprise's asset, liability, and derivatives positions are well matched, the effects will be minimal. But if, for example, an Enterprise were to fund long-term, fixed-rate mortgages with short-term debt, then an increase in market yields would cause the value of the mortgages to fall, but the value of the short-term debt would be little changed. In subsequent periods, interest income on the mortgages would be unaffected, but interest expenses would be higher because new debt would need to be issued at the new higher interest rate. Earnings and equity would suffer. Conversely, a fall in market yields would increase the value of the mortgages, and that higher value would be reflected in subsequent earnings and equity gains. If an Enterprise were to fund short-term assets with long-term, fixed-rate debt, its debt would change in value, but its assets would not, producing the opposite effect.

If changes in interest rates continue over a period of time, then a decision to issue long-term debt or purchase long-term assets in the middle of the stress period would create a new source of changes in value over the remainder of the period. The effects of the change in interest rates on future earnings and equity would then reflect the changes in value of both the original positions and the new long-term debt or assets.

In the proposed stress test, interest rates change substantially and continuously during the first year of the stress period and then are constant in the last nine years. If an Enterprise were projected to issue long-term debt or purchase long-term assets during the first year, the new investments would change in value during the remainder of the year and affect subsequent earnings and equity. Such an approach would distort the stress test's evaluation of starting risk positions.

The proposed rule avoids these problems by making all new debt and investment short-term instruments. Investments are made in Treasury bills to avoid introducing credit risk; new debts are in the form of discount notes. Maturities of six-months were chosen as a representative short term.[183]

2. Analysis of ANPR Comments

In the ANPR, OFHEO posed several questions related to new debt and investments during the stress period. HUD and ACB recommended in their comments that OFHEO develop an econometric model of Enterprise funding decisions. OFHEO believes, however, that it would be inappropriate to build such a model. The factors that would have to be incorporated into such a model would require OFHEO to make complex judgments about the decisions an Enterprise's management might make in response to future economic conditions. HUD's comment that ''OFHEO may be able to base modeling of GSE liability management * * * on presumptions concerning how GSEs would formulate and exercise broad financial management objectives during a winddown'' would require similar judgments. ACB also commented that ''excess cash balances should be assumed to be deployed to minimize remaining interest rate risk exposure since the costs of such a hedging strategy are zero.'' OFHEO determined that this approach could change the risk profile of an Enterprise during the course of stress period and is, therefore, inappropriate for the stress test.

Freddie Mac also addressed the question of new debt in the stress test. Freddie Mac proposed that OFHEO assume the Enterprises would generally adhere to their respective asset and liability management principles in a stress test environment. More specifically, the Enterprises would rebalance their portfolios of assets and liabilities during the stress period, in an attempt to maintain a specific relationship between the net effective maturity and net callability of assets and liabilities. Freddie Mac further suggested that OFHEO should use a simple rule that includes this concept for the issuance of new debt in the stress test. As a possible rule, Freddie Mac offered the following example: 30 percent short-term and 70 percent long-term debt in the up-rate scenario and 70 percent short-term and 30 percent long-term debt in the down-rate scenario. The intent of the stress test is, however, to test the ability of an Enterprise's initial asset and liability mix to survive stressful conditions. Therefore, OFHEO preferred an approach that did not

[182] In a stress test that incorporates new business, the context would be different. Should OFHEO choose to incorporate new business in a later regulation, a different approach to asset-liability management during the stress period could be appropriate. See 1992 Act, section 1361(a)(3)(C) (12 U.S.C. 4611(a)(3)(C)).

[183] Recurring patterns in cash flows can cause an Enterprise to hold substantial volumes of new six-month investments at the same time that it has substantial volumes of new six-month debt outstanding. This creates an unnecessary balance sheet expansion. A more realistic solution would be to assume that maturities of new debts and investments were spread across a variety of terms less than one year. OFHEO proposes to approximate that result by assuming that any outstanding new six-month investments are redeemed at par at the end of each month.

actively alter the consequences of the interest rate risk exposure inherent in the Enterprises' business at the beginning of the stress period.

At HUD's suggestion in its comments on the ANPR, OFHEO reviewed the role of new debt in the wind down scenarios described in HUD's *1987 Report to Congress on FNMA*, issued on September 27, 1989. Although OFHEO agrees with HUD that there is a close connection between investing cash, hedging activities, and liabilities, OFHEO believes that the purpose of the ''no new business'' stress test is to project the results of existing risk positions in stressful environments. This approach differs significantly from HUD's 1987 wind down scenarios, which were designed to project Fannie Mae's performance during an intentional wind down of Fannie Mae's mortgage portfolio in preparation for a hypothetical privatization of that Enterprise.

I. Operating Expenses

Operating expenses include non-interest costs, such as those related to an Enterprise's salaries and benefits, professional services, property, and equipment. The operating expenses of each Enterprise comprise a relatively small portion of their overall expenses. For instance, in 1997, Freddie Mac's interest-related expenses were $10.6 billion, while its operating expenses were $495 million. Similarly, Fannie Mae's interest-related expenses were $22.4 billion, while its operating expenses were $636 million that year.

The 1992 Act is silent on how operating expenses should be treated in the stress test. Nevertheless, the legislative history states that the Director should exercise discretion about variables such as the Enterprises' operating expenses, provided that they are ''reasonable and to the extent possible based on historical data.'' [184] In addition, the stress test's treatment of operating expenses is guided by the 1992 Act's ''no new business'' requirement.[185] That provision requires OFHEO to project the income and expenses associated with the existing business positions of the Enterprises over a ten-year period. The purpose of the ''no new business'' requirement is for the stress test to capture the risks of an Enterprise's existing assets, liabilities, and off-balance sheet obligations as of the beginning of the stress period. It is not intended to represent any combination of events that might occur in the actual course of an Enterprise's business activities.

In the proposed regulation, operating expenses decline during the stress period in direct proportion to the decline in the volume of each Enterprise's total mortgage portfolio (i.e., the sum of the outstanding principal balance of its retained and sold mortgage portfolios). The stress test first projects how an Enterprise's mortgage portfolio decreases during the stress period on a monthly basis. After determining the percent of these assets that remain at the end of any month during the ten-year stress period, OFHEO simulates the reduced operating expenses in each month by multiplying this percent by one-third of the amount of the Enterprise's operating expenses in the quarter immediately preceding the start of the stress test. This computation is used to determine the Enterprises' operating expenses for each month of the stress period. As described in more detail in this section below, under this approach, the expense reduction pattern for the up-rate scenario will differ from the down-rate scenario, and the pattern within each scenario will vary depending on changes in the characteristics of an Enterprise's total mortgage portfolio.

In the ANPR, OFHEO raised several questions about how the stress test should model operating expenses. These issues are considered below.

OFHEO first considered whether there should be any reduction in operating expenses during the stress period. The stress test should include such a reduction because many of the Enterprises' operating expenses are tied to the size of their mortgage portfolios. Both commenters on this issue, Freddie Mac and ACB, supported this view.

OFHEO next considered whether there should be a variable or straightline reduction in operating expenses. OFHEO determined that a variable reduction pattern would be more appropriate. The underlying characteristics of mortgages held or guaranteed by an Enterprise or the interest rate conditions of the stress period would substantially affect the rate of reduction in outstanding mortgage balances. Because a large portion of expenses are directly tied to outstanding loan balances, a variable reduction based on those balance patterns will better correspond with the cost reductions that would occur under the stress test scenarios.

Notwithstanding this general approach, OFHEO notes that expenses in some categories are not closely tied to current loan balances. These expenses might be expected to change at different rates from loan balances in a stressful no-new-business environment. As Freddie Mac commented in response to the ANPR, a large portion of its operating expenses are associated with either new business or long-term research and development, including product and systems development, and so might be reduced more dramatically under a no-new-business assumption. Conversely, Freddie Mac stated that some other operating costs that are associated with ongoing costs of managing the mortgage portfolio are relatively fixed, i.e., they are independent of the size of the portfolio. On balance, tying expenses to loan balances will produce a reasonable approximation of an Enterprise's costs in the stress test scenarios.

The proposed approach to modeling operating expenses differs from the recommendations made by ACB and Freddie Mac. Rather than a variable approach, these commenters favored a model applying a straightline reduction in operating expenses. Freddie Mac commented that a straightline approximation is sufficient, because the resulting capital requirement should depend primarily on the present value of the operating expenses and not on the exact timing of those expenses. However, OFHEO believes it is appropriate to adopt an approach that more precisely takes timing into consideration, because the timing of expenses affects an Enterprise's performance during the stress test and the resulting risk-based capital requirement. Furthermore, a straightline approach still requires a basis on which to determine the rate of expense reduction. The proposed approach simultaneously takes timing into account and determines the overall rate of reduction.

The next issue concerned whether the model should reflect decisions that might be made by an Enterprise if it was intentionally winding down its business. On that issue, HUD recommended two alternative approaches: either that OFHEO model the behavior of an Enterprise on issues such as liability management, dividend policy, and operational management as if it were aware that a wind down is in effect, or that OFHEO proceed in a ''more formalistic fashion,'' i.e., without regard to whether they did or did not know. OFHEO analyzed this issue, not only within the context of operating expenses, but also as it relates to the underlying concepts of the stress test and many of its components. OFHEO determined that it would be inconsistent with the 1992 Act and the overall purposes of the stress test for the

[184] H.R. Rep. No. 102–206, at 65 (1991).

[185] 1992 Act, section 1361(a)(3)(A) (12 U.S.C. 4611(a)(3)(A)).

model to attempt to reflect decisions that would be made by an Enterprise that was intentionally winding down its operations. Instead, the stress test applies the alternative approach discussed by HUD in which an Enterprise would not know that a wind down was in effect. As discussed earlier, this approach is appropriate because the stress test is intended to capture the actual risks of an Enterprise's existing business as of the beginning of the stress period rather than events that might occur during the actual course of its business.

OFHEO next considered whether it is appropriate to treat categories of operating expenses differently. OFHEO has determined that disaggregating the operating expenses into several categories would add needless complexity without providing any significant corresponding benefit to ensuring an Enterprise's capital adequacy. While some expense categories might reasonably be assumed to decline faster than the mortgage portfolio, some others might decline more slowly, and some might be expected to increase. OFHEO agrees with ACB and Freddie Mac that since operating expenses constitute a relatively small portion of an Enterprise's overall costs, they should not be subject to complicated modeling. Accordingly, OFHEO proposes to consider operating expenses in a single category rather than disaggregating them into distinct categories.

Finally, OFHEO considered whether the operating expenses of each Enterprise should be modeled in the same manner. Freddie Mac recommended that instead of distinguishing between the Enterprises, the stress test should reduce operating expenses of each Enterprise in the same manner. Freddie Mac stated that any attempt to make fine distinctions between how each Enterprise might actually manage its operating expenses during the stress period could lead to extensive analysis that ought to have little affect on the overall capital requirement but, could increase the danger of different capital treatment for each Enterprise based on differences in accounting treatment of expenses.

OFHEO agrees with Freddie Mac's recommendation not to distinguish between the Enterprises with respect to modeling operating expenses. A fundamental concept of the risk-based capital requirement is that the stress test establish a single set of rules that apply equally to both Enterprises. It would be inappropriate to establish a different stress test for each Enterprise. As a result, differences in operating expenses during the stress test between the Enterprises will reflect only differences in initial expense levels and mortgage portfolio composition, not any projected behavioral differences.

J. Dividends and Other Capital Distributions

1. Introduction

The definition of a ''capital distribution'' in the 1992 Act includes the payment of common stock dividends, preferred stock dividends, and the repurchase or retirement of shares of stock.[186] In recent years, both Enterprises have consistently paid significant amounts of dividends and have repurchased significant amounts of common stock.

The 1992 Act directs OFHEO to consider dividends in the stress test. When an Enterprise makes a capital distribution and the amount of that distribution, however, are not specified in the 1992 Act. The only requirement is that dividends should be consistent with the stress test environment.[187] Because capital distributions decrease equity, the more distributions an Enterprise makes during the stress test period (or during a real-life stressful environment), the more likely that an Enterprise will fail to meet its risk-based capital requirement.

2. Statutory Provisions

The 1992 Act and the Charter Acts determine the authority of the Enterprises to make capital distributions.[188] Under these statutes, an Enterprise may make a capital distribution without restriction when the Enterprise would remain adequately capitalized following the distribution.[189] In all other circumstances, a capital distribution is prohibited outright or requires the approval from the Director of OFHEO.

Prior approval by the Director is required when an Enterprise is undercapitalized or if a capital distribution would cause the Enterprise to be undercapitalized.[190] The legislative history of this requirement makes clear that, while approval in these circumstances can be granted, such approval ''should be the exception and not the rule.'' [191] The Director's prior approval also is required when an Enterprise is significantly undercapitalized; however, the 1992 Act places conditions on the granting of such approval. In those circumstances, the Director may only approve a distribution if the Director determines that it will: (1) Enhance the Enterprise's ability to meet its capital requirements, (2) contribute to the Enterprise's long term safety and soundness, or (3) is otherwise in the public interest.[192] No approval may be granted for a distribution that would cause the Enterprise to be significantly undercapitalized or critically undercapitalized.[193]

This statutory structure draws a clear distinction between an Enterprise that fails to meet its risk-based requirement and one that fails to meet its minimum capital requirement. When an Enterprise fails to meet the risk-based capital requirement, the Director has full discretion to grant or deny approval for a capital distribution. However, when an Enterprise fails to meet the minimum capital requirement, the Director's discretion is limited. Moreover, the Director is prohibited from approving a distribution that would cause the Enterprise to fail to meet the minimum capital requirement.

3. Proposed Approach

The proposed regulation provides that during the stress period:

- When paid, dividends are paid at rates consistent with historical experience;
- Dividends are paid on common stock when the Enterprise meets the risk-based capital requirement and the minimum capital requirement;
- Dividends are paid on preferred stock when the Enterprise meets the minimum capital requirement; and
- No dividends are paid when the Enterprise does not meet or would not

[186] 1992 Act, section 1303(2)(A) (12 U.S.C. 4502)(A)). The notable exception is the repurchase of shares for employee stock ownership programs under section 401 of the Internal Revenue Service Code of 1986.

[187] 1992 Act, section 1361(b)(2) (12 U.S.C. 4611(b)(2)). ''Characteristics of the stress period other than those specifically set forth in subsection (a), such as prepayment experience and dividend policies, will be those determined by the Director, on the basis of available information, to be most consistent with the stress period.''

[188] Fannie Mae's Charter Act and Freddie Mac's Corporation Act collectively are referred to as the ''Charter Acts.''

[189] In general, an Enterprise is considered ''adequately capitalized'' when it meets both the risk-based and minimum capital levels. It is ''undercapitalized'' when it does not meet the risk-based capital level, but does meet the minimum capital level. It is ''significantly undercapitalized'' when it does not meet either the risk-based capital level or the minimum capital level, but does meet the critical capital level. *See* section 1364 of the 1992 Act (12 U.S.C. 4614), and section 303(c)(1) of the Charter Act and section 303(b)(1) of the Corporation Act.

[190] Section 303(c)(2) of the Charter Act and section 303(b)(2) of the Corporation Act.

[191] S. Rep. No. 102–282, at 24 (1992).

[192] 1992 Act, section 1366(a)(2) (12 U.S.C. 4616(a)(2)).

[193] 1992 Act, sections 1365(a)(2); 1366(a)(2)(A) (12 U.S.C. 4615(a)(2); 4616(a)(2)(A)).

after payment of the dividend meet the minimum capital requirement.

In making this proposal, OFHEO emphasizes that there are significant differences between establishing a dividend payment policy for the risk-based capital requirement and acting on a dividend approval request from an Enterprise that is no longer adequately capitalized. Accordingly, provisions of the stress test which provide for the payment of dividends by an undercapitalized Enterprise in some circumstances and not others should not be interpreted as an indication of how OFHEO will act on any specific dividend approval request. In practice, OFHEO will evaluate any request for approval of a dividend payment on the basis of a case-by-case analysis of all the relevant facts and circumstances.

a. Preferred Stock

Under the proposed regulation, dividends are paid on preferred stock during the stress period when the Enterprise meets its estimated minimum capital requirement. Preferred stock dividends are based on the coupon rates of the issues outstanding. The coupon rates for any issue of variable rate preferred stock is calculated using projections of the appropriate index rate.

To determine whether the Enterprise meets the minimum capital requirement, the stress test computes the minimum capital level each month by applying the appropriate leverage ratios to all assets (2.50 percent) and off-balance sheet obligations (0.45 percent). OFHEO notes that interest rate and other off-balance sheet contracts also affect the minimum capital number.[194] However, incorporating these features in the calculation would require OFHEO to compute the credit equivalent amount of interest rate and foreign exchange contracts, which would add unnecessary complexity but provide little corresponding benefit. Accordingly, for purposes of determining dividend payouts in the stress test, OFHEO believes that the approach described above provides a reasonable approximation of the minimum capital calculation.

As noted above, preferred stock dividends are paid in some circumstances in which common stock dividends are not paid. The stress test includes this distinction based on the recognition that when a corporation issues preferred stock, it is making a higher level of commitment to those investors than when it issues common stock. Preferred stockholders have a first claim on distributions. Therefore, failure to pay dividends on both classes of stock likely would have greater repercussions on an Enterprise's funding costs and ability to attract new equity capital than would a failure to pay common stock dividends while preferred stock dividends were maintained. Accordingly, when an Enterprise is classified as undercapitalized, the stress test pays preferred stock dividends, but not common stock dividends.

b. Common Stock

Under the proposed regulation, dividends are paid on common stock during the first four quarters of the stress period. The stress test specifies that common stock dividends cease after that, reflecting the strong likelihood that an Enterprise would not meet the risk-based capital requirement during the final nine years of the stress period. The rate at which dividends are paid is based on the trend in the Enterprise's earnings. If earnings are positive and increasing, dividends are paid based at the same dividend payout ratio as the average payout ratio of the four quarters preceding the stress test. Otherwise, dividends are paid based at the preceding quarter's dollar amount of dividends per share. Dividends would be cut off before the end of the first year if an Enterprise failed to meet its estimated minimum capital requirement.

OFHEO believes this rule is based on a reasonable representation of when an Enterprise will no longer be adequately capitalized. The conditions of the stress test are sufficiently stressful to assure that the Enterprise would be undercapitalized by the end of the first year of the stress period. By that time, an Enterprise's portfolio would have been subjected to very large interest rate increases or decreases. If, at that point, it was subjected to those same large increases, i.e., a total of up to 1200 basis points over two years, it is reasonable to assume that the Enterprise would be undercapitalized. The Enterprise would have to withstand more severe credit losses because the hypothetical stress tests would also compound declines in house prices associated with the actual stress test. Estimating with greater accuracy whether an Enterprise would meet its risk-based capital requirement at any time during the stress period is inherently difficult. This would require simulating a series of hypothetical ten-year stress tests, the last of which would involve generating cash flows extending ten years beyond the end of the actual stress period. This would add great technical complexity to the stress test without providing any meaningful benefit.

c. Other Types of Capital Distributions

The proposed regulation does not provide for any other types of capital distributions, such as repurchases of common stock, or redemption of preferred stock. Although the Enterprises have both repurchased a significant number of shares of their own common stock in the past several years, the stock buybacks were irregular events based on the current share price, expected return on potential investments, and the profitability of each Enterprise. The Enterprises have made no firm commitment to investors to continue share repurchases. Furthermore, OFHEO believes that the stress test environment would not be conducive to share repurchases.

4. Analysis of ANPR Comments

In response to questions in the ANPR, Freddie Mac emphasized that any assumptions that OFHEO makes regarding dividend payments must be consistent with the 1992 Act, particularly the provisions related to how capital classifications affect dividend payments. With regard to preferred stock dividends, Freddie Mac recommended that OFHEO assume that an Enterprise pays dividends on such stock so long as it satisfies its minimum capital requirement and discontinues preferred dividends thereafter. With regard to common stock dividends, Freddie Mac recommended that OFHEO assume that an Enterprise pays a constant dividend payout ratio on common stock until earnings become negative, at which time common stock dividends would be discontinued.

The proposed regulation, which ties dividend payouts to capital classifications, is consistent with the 1992 Act and is generally consistent with Freddie Mac's recommendations. More specifically, OFHEO agrees with Freddie Mac's recommended approach for paying preferred stock dividends until an Enterprise's capital falls below the minimum level. OFHEO believes this treatment of preferred stock dividends properly reflects the high level of commitment of the Enterprises to investors in their preferred stock.

In addition, eliminating common stock dividends after an Enterprise becomes undercapitalized is roughly equivalent to Freddie Mac's recommendation to cut off common stock dividends when an Enterprise's earnings turn negative. However, while Freddie Mac would reduce dividends proportionately if earnings decline, the proposed regulation provides for the

[194] 12 CFR 1750.4.

payment of a constant dollar amount. OFHEO believes the payout rule in the stress test appropriately reflects the current dividend payout history of the Enterprises. Both Enterprises have made fairly strong commitments to investors regarding dividend payouts, and have been slow to lower their dividend payments in the face of declines in earnings.

ACB recommended that dividends be suspended immediately in the stress test, since the Enterprises are assumed to be in a wind down and shareholders would be strictly residual claimants. ACB's recommendation to suspend all dividends immediately is not consistent with the apparent intent of the 1992 Act, which specifically mentions dividend policies and directs OFHEO to consider dividend policies that would be ''most consistent with the stress period.''[195] As discussed above, OFHEO believes that the proposed capital distribution rule is consistent with the stress test period. Furthermore, the stress test would fail to incorporate a likely source of capital depletion that would affect an Enterprise in a real-life stressful environment if all capital distributions were eliminated during the entire stress test period.

ACB's comment that shareholders would be strictly residual claimants, which implies that the stress test is a liquidation situation, is not consistent with the concepts underlying the stress test. A wind down or ''no new business'' stress test is not the equivalent of a liquidation. Rather, it is a test of how much capital an Enterprise would need to survive.

K. Other Off-Balance Sheet Guarantees

In addition to guaranteeing mortgage-backed securities they issue as part of their mainline business, the Enterprises occasionally guarantee other securities. Such guarantees are referred to as ''other off-balance sheet (OBS) guarantees.'' Examples of other OBS guarantees include guarantees of tax-exempt multifamily housing bonds issued by state and local government agencies, Enterprise-issued whole loan REMIC securities to security, and private label (non-GSE-or GNMA-issued) REMIC securities. In general, an Enterprise's guarantee is protected by other credit enhancements, including reserve funds, insurance arrangements, and/or subordinated security tranches.

For the following reasons it is not now feasible to simulate the detailed financial impact on an Enterprise of other OBS guarantees over the 120 months of the stress period. First, the mortgage collateral for such securities is often dissimilar from the Enterprise's mortgages on which the stress test's mortgage performance models are based. Second, current data on the status of the underlying collateral is difficult to obtain. Third, the structures of the securities and the nature of credit enhancements vary, requiring the individual modeling of each guaranteed security, which would, at this time, require an inordinate amount of resources.

The stress test utilizes a proxy for the detailed modeling of the impact of other OBS guarantees on the amount of starting capital that an Enterprise would need to just maintain positive capital during the stress period. The proxy treatment consists of multiplying the outstanding balance of all other guarantees at the beginning of the stress period by .0045, and adding the result to the amount of starting capital calculated for all other aspects of an Enterprise's operations. The multiple .0045 corresponds to the minimum capital requirement associated with these other OBS guarantees.

L. Calculation of the Risk-Based Capital Requirement

1. Proposed Approach to Calculating Capital

The 1992 Act requires an Enterprise to meet the risk-based capital requirement. To determine this requirement, the statute establishes a two-step process. The first step is to determine the amount of capital that an Enterprise needs to just maintain positive capital during a ten-year period of economic stress. The second step is to increase that amount of capital by another 30 percent to capture management and operations risk.

OFHEO proposes to use a present value approach to calculate the capital that an Enterprise needs to just maintain positive capital during the stress test. Once the stress test has projected the capital of an Enterprise at the end of every month in the stress period, the capital calculation process discounts the monthly capital balances back to the start date of the stress period. The Enterprise's starting capital is then adjusted by subtracting the lowest of the discounted capital balances to account for the smallest capital excess or largest deficit (subtracting a negative number in the case of a deficit). The discount factor used to discount a monthly capital balance is based on after-tax borrowing or investing yields (as appropriate) for that month and all previous months during the stress period.

After the stress test ascertains the amount of capital necessary to just maintain positive capital during the stress test, it then multiplies that amount by 1.3 to arrive at the risk-based capital requirement.

2. Justification for Using a Present Value Approach

The 1992 Act requires OFHEO to determine the amount of capital that is sufficient for an Enterprise to just maintain positive capital during the ten-year stress period. However, when an Enterprise has more (or less) capital than it needs to just maintain positive capital, the law does not specify the procedure for calculating how much capital it would need to just maintain positive capital.

In analyzing the best method to calculate capital during the ten-year stress period, OFHEO considered two approaches: (a) the present value approach, described above, and (b) an ''iterative approach'' in which the stress test would be run multiple times with hypothetical adjustments made to each Enterprise's balance sheet prior to each run. The present value approach more efficiently produces results comparable to the iterative approach. Both approaches recognize that a dollar today is worth significantly more than a dollar ten years from now, because the dollar can be invested so as to return more in a later year.

Under the iterative approach, the capital calculation process begins by running the stress test on the basis of an Enterprise's actual assets, liabilities, net worth, and off-balance sheet items as of a given date. The first stress test run would be used to identify the lowest capital balance that the Enterprise has during the stress period. Then, based on that result, adjustments would be made to the starting capital and the assets and/or liabilities on the Enterprise's balance sheet. The goal of these adjustments is to construct a starting position book of business that, when subject to the stress test, will result in the Enterprise just maintaining positive capital during the stress test. If a run results in the Enterprise's capital reaching a minimum point greater than zero, OFHEO would reduce the starting capital in order to move the minimum point down toward zero in the next run. If a run resulted in the Enterprise's capital reaching a minimum point less than zero, then OFHEO would increase the starting capital in order to move the minimum point up toward zero in the next run. If the second run did not achieve the desired result, successive runs would be made following further

[195] 1992 Act, section 1361(b)(2) (12 U.S.C. 4611(b)(2)).

adjustments to the starting position balances.

OFHEO is proposing the present value approach rather than the iterative one based on the following considerations. The present value approach is comparatively simple and easy. It will not require explicit changes to an Enterprise's actual assets, liabilities, net worth, and off-balance sheet items as they exist at the start of the stress test, and it achieves results comparable to the iterative approach. It achieves these results because the discount factors used in the present value calculations, which calculate the surplus or deficit of starting capital, are consistent with the effects during the stress period of the balance sheet adjustments required by the iterative approach. The discount factors reflect the yields on additional debt or investments offsetting necessary changes in starting capital. For example, consider a scenario in which an Enterprise holds more starting capital than necessary to maintain positive capital throughout the stress period. Balance sheet adjustments made for the final iteration would likely involve substituting for the surplus starting capital an equal amount of debt. Discounting the appropriate monthly capital balance during the stress period, using stress period yields, results in a comparable amount.

Based on these considerations, the present value approach would be a more appropriate methodology for carrying out the purposes of the statute. The iterative approach would add needless complexity and require OFHEO to make changes to the balance sheets of the Enterprises. Each iterative run, would be based on hypothetical representations of the Enterprise's position. The present value approach eliminates the need for these artificial adjustments and the unwarranted complexity that the iterative approach's adjustment process would entail.

Under the present value approach, it is necessary to determine the appropriate monthly discount rates. In determining the monthly rates, OFHEO sought a set of discount rates that would reflect the time value of money to an Enterprise during the stress period. Accordingly, the discount rates applied in the stress test are computed as an after-tax rate. Such an after-tax rate reflects the fact that any borrowing necessary to fund an Enterprise's business activities would be deductible for income tax purposes. Conversely, any additional earnings would be subject to income taxes.

These discount rates are intended to reflect the fact that interest rates will differ dramatically between the rising and falling rate scenarios and at given times in each scenario. When an Enterprise is borrowing new funds during the stress period, the marginal effect that a change in its cash position in one month will have on its equity in a subsequent month will be reflected by its after-tax cost of borrowing during the intervening period. Alternatively, if the Enterprise is a net investor in a given month, the marginal effect is reflected by its after-tax earnings on new investments in Treasury bills.

This discounting procedure will reasonably relate changes in capital to changes in an Enterprise's risk position. For example, if an Enterprise were to take an incremental risk position that resulted in an incremental loss during the first month of the stress period, that loss would compound during the stress period at the Enterprise's after-tax borrowing or investment rate. If an Enterprise is borrowing, this one month's incremental additional loss would require additional borrowings during the balance of the stress period. These additional borrowings would create additional interest payments for which further borrowing would be required. If the Enterprise is investing, the loss would leave smaller amounts to be invested, which would earn less interest. After applying the discount factors, the change in each future month's capital would equal the initial loss. Thus, the change in the estimated amount of the first month's incremental capital needed to just maintain positive capital during the stress test would also equal that initial loss. More generally, if a new asset were to generate a stream of losses over the course of the stress period, the amount of starting capital needed would rise by the present value of this stream of losses.

IV. Technical Supplement

A. Purpose and Scope

This technical supplement provides detail on the specification and estimation of statistical (econometric) models for mortgage performance, and how those statistical models are applied in the proposed risk-based-capital stress test. The supplement focus is on technical aspects of the statistical modeling. This focus includes: theoretical considerations, sources and uses of historical data, functional forms for statistical models, development of explanatory variables for the statistical analyses, results of statistical model estimations, and application of the resulting statistical equations to predict mortgage performance in the stress test. Each of the following parts of this supplement covers these elements for its respective part of mortgage performance. The topic areas covered here are:

- Single Family Default/Prepayment,
- Single Family Loss Severity,
- Multifamily Default/Prepayment,
- Multifamily Loss Severity, and
- Property Valuation.

An additional, and important component of this Supplement is the description of how the statistical models of mortgage performance are reasonably related to the benchmark loss experience (BLE) identified in NPR1. The first way in which OFHEO reasonably relates the mortgage performance component of the stress test to the BLE is through application of housing market conditions that represent the conditions of that experience. Those conditions include house price growth rates, rent growth rates, and rental vacancy rates. The next part of this supplement, Property Valuation, details how OFHEO developed these variables for use in the stress test. How these variables are actually used in the stress test is covered in the section 3.5, Mortgage Performance, of the Regulation Appendix, although some general information is provided here.

The second way in which mortgage performance in general, and credit losses in particular, are related to the BLE is through calibration mechanisms that adjust statistically derived equations to match the actual loss rates of the BLE. These adjustments are required because the statistical equations are estimated over a wide range of data, of which the benchmark experience is only a small part. To reasonably relate mortgage losses to the BLE, the stress test imposes housing market conditions from the time and place of the BLE. In addition, the stress test adjusts defaults and severities by factors that cause the test to replicate critical aspects of the BLE when the statistical models are applied to benchmark loans. The methods of deriving these calibration adjustment factors are described in the Single Family Default/Prepayment and Single Family Loss Severity parts of this Supplement.

B. Single Family Default/Prepayment

1. Introduction

To develop the stress test model of single family default and prepayment rates, OFHEO analyzed the historical experience of Enterprise single family loans from 1979 through 1995. This experience is defined by an econometric model in which probabilities of default and prepayment in each time period are

determined jointly using a multinomial logit specification. The theoretical foundation used for choosing variables to use in the model is financial options theory. This is the predominant theory used in mortgage performance research. It suggests that borrowers make choices regarding maintaining or terminating mortgages based upon the relative financial value of those choices. In this context, each borrower has the choice, in each time period, to make the payment and maintain the mortgage, pay off the mortgage in full (a prepayment), or stop making payments and default.

Owing to the large amount of data available to estimate this model, OFHEO chose techniques that captured the essence of individual borrower choice, consistent with efficient use of computer resources. These techniques start with estimating separate sets of default and prepayment equations for fixed-rate mortgages (FRMs) and for adjustable-rate mortgages (ARMs).[196] A third set of equations was estimated to project the performance of less-prevalent single family loan types relative to the dominant 30-year fixed-rate mortgages. The second method of capturing borrower choice characteristics while limiting computer resources was to use random samples of fixed-rate loan products, rather than attempting to estimate the model on all loans ever purchased by the Enterprises. The third method was to use quarters rather than months as the observation time period. This time period is important because each loan enters the analysis in the form of an event history: every time period for which the loan was active provides an observation for the statistical analysis. Using quarters reduces the number of observations used in the statistical analysis without losing any essential detail regarding borrower choices. The last method of maintaining the quality of individual loan analysis while limiting computer resources was to use a weighted regression scheme, so that all loans do not need to enter the analysis individually. All loans with the same characteristics are treated as one loan, with the actual number of loans with those characteristics used as a weighting factor.

The equations that result from the statistical analysis were adjusted or calibrated to the BLE before use in the stress test. The calibration procedure adjusts the default equations so that if the actual benchmark loans (as defined in NPR1) were input into the equations, with benchmark house price growth rates and interest rates, the resulting 10-year cumulative default rate would identically match that of the BLE (14.9 percent).

The remainder of this supplementary material is organized as follows: Section 2 provides a summary of the conceptual framework underlying the estimation of the statistical model of single family mortgage default and prepayment. Section 3 describes the loan level data used in the empirical analysis. Section 4 outlines the general approach to the statistical analysis of default and prepayment events, based on the application of the multinomial logit model. Section 5 defines the explanatory variables used in that analysis. The empirical results are presented in section 6, which is followed in section 7 by a discussion of the application of the estimated default and prepayment equations in the stress test. Section 8 ends this supplementary material by describing how the estimated model is used in the stress test to produce results consistent with the BLE.

2. Conceptual Framework

Financial options theory is the most widely accepted theoretical framework for the analysis of residential mortgage default and prepayment. This framework hypothesizes that mortgage borrowers will exercise embedded call (prepayment) or put (default) options when either of these alternatives becomes financially optimal. The financial options theory assumes that an individual mortgage borrower can increase his lifetime wealth by defaulting on a mortgage when the market value of the mortgage exceeds the market value of the house, implying a direct empirical link between changes in housing values, borrower equity, and the decision to default. Likewise, the option to refinance the mortgage when market rates fall below the current rate on the mortgage provides a means for borrowers to increase their wealth by prepaying, and links observed prepayment behavior to changes in interest rates.[197]

Previous empirical studies on mortgage terminations have provided empirical support for the options theory, as various approximations to the financial values of the options have been found to be strongly associated with observed default and prepayment outcomes.[198] However, some of the same studies also indicate that borrowers do not behave in the ''ruthless'' manner suggested by the pure options theory. These empirical studies vary in the degree to which the full implications of the theory are incorporated, mainly due to limitations on the available data and the ability to measure or impute options values to individual borrowers.

The measurement of borrower equity has been addressed in essentially two ways in the academic literature. One approach employs stochastic simulations to impute aggregate distributions of properties with positive or negative equity, while simultaneously accounting for the impact of default and prepayment events on these distributions. This is the approach used by Foster and Van Order (1984, 1985). Another approach, adopted in recent work by Deng, Quigley, and Van Order (1996) and Deng (1997), has been to combine mathematical assumptions about the diffusion of housing values with loan-level data to assign ''ex ante'' probabilities of negative equity to individual properties.[199] Both approaches are generally consistent with the assumptions of the option theory, and they differ mainly in their application to aggregate versus loan-level data.

In recent years, a consensus seems to have emerged among practitioners that the option values, to the degree that they can be measured, remain important for predicting default and prepayment,

[196] In this model, ARMs include all mortgages that have variable payment features.

[197] There may also be secondary effects of borrower equity on prepayment, and of interest rates on default. For example, attempts by borrowers to prepay their mortgages may be frustrated due to declining house prices and failure to qualify for refinancing. On the other hand, borrowers in a negative equity position may be reluctant to default if they have current mortgage coupon rates that are less than the prevailing market rate of interest. In this second case, the asset value of the low interest rate mortgage would be foregone if the put option is exercised and the borrower defaults. However, the empirical significance of mortgage value for default is questionable given the inability of borrowers to trade on this asset, other than by selling the property and taking back a mortgage at a rate between the original note rate and the current market rate. This option is precluded by the ''due-on-sale'' provisions of most residential mortgage contracts. The extent to which this option is used informally is unknown.

[198] Examples of empirical models based on the options framework include: Dunn and McConnell (1981), Foster and Van Order (1984, 1985), Buser and Hendershott (1984), Brennan and Schwartz (1985), Kau, Keenan, Muller, and Epperson (1985, 1990), and Hendershott and Van Order (1987).

[199] Probabilities assigned in this way are ''ex ante'' because they depend only on information about individual mortgages available at origination and subsequent changes in the mean (drift) and variance (volatility) of house price appreciation rates. No information on the incidence of default or prepayment among other loans is used to adjust the projected distribution of housing values used to assign probabilities of negative or positive equity to loans that remain active.

but provide only necessary, rather than sufficient, conditions. For example, in the case of mortgage default, negative equity alone may not be sufficient to induce a borrower to default, but given some other ''trigger event,'' such as job loss or marital disruption, the decision to default would then depend on whether equity was positive or negative. In the case of prepayment, borrowers who would otherwise appear to have a financial incentive to refinance (prepay) to obtain a lower interest rate, may not wish to incur the associated transactions costs given their expected time horizons for occupying the home.

While the option theory succeeds as a general framework, empirical models of mortgage default and prepayment must be flexible enough to account for variation in mortgage performance that may not appear to be fully consistent with optimal behavior, such as borrowers defaulting when house prices are increasing or prepaying when interest rates are increasing. The empirical model must account for limitations on the information available to compute the exact values of embedded options for individual borrowers. In addition, a wide variety of loan characteristics must also be accounted for, which has led to the widespread application of what are generally referred to as ''options-based'' empirical models, such as those cited above. The models applied in the stress test are typical of those that use the options-based approach.

3. Data

OFHEO obtained loan-level information on previous Enterprise single family mortgage originations and used these data to estimate models of mortgage performance. The data included information on the origination characteristics of mortgages, information on last-paid installment dates, and loan status outcomes from the Enterprise loan-tracking systems. This information allowed OFHEO to reconstruct ''event histories'' of the period-by-period performance of individual loans, from the date of origination to either the point where the loan terminated or the end of the sample period. OFHEO combined loan-level information from both Enterprises to develop its own data files for statistical analysis. Standardized or ''normalized'' data files were constructed to assure similar content and structure across Enterprises.[200]

[200] The process of data normalization involved confirming the consistency of mortgage product types and loan characteristics and defining standardized data fields.

The options theory views mortgage default and prepayment events in terms of decisions by individual borrowers to terminate their loans. This view has implications for the way mortgage outcomes and their associated probabilities are specified in the statistical analysis. Default and prepayment are specified to occur in the month following the date of the last-paid-installment. After mortgage prepayment, the Enterprises are likely to update the loan status almost immediately. By contrast, due to the varying length of the mortgage foreclosure process, the Enterprises may not classify defaulting loans as defaults until some months after the last-paid-installment date. However, in the model, the default event is nevertheless considered to have occurred at the point the borrower ceases payment on the loan.[201] The event history used for that loan ends at that point in time. The data used in the statistical analysis included mortgage originations for the period from January 1979 to December 1993, with mortgage performance measured through December 1995. Therefore, these data provided a minimum of two years of loan experience for the most recent origination cohorts.[202]

Ideally, models would be estimated using contemporaneous values of factors predictive of default and prepayment during each period a loan is outstanding. Although this type of ''panel'' data does not exist for historical Enterprise loan records, it was possible to reconstruct historical data on key determinants of default and prepayment, such as house prices and interest rates, and add this information to the individual loan event histories. Using these histories, OFHEO was able to estimate dynamic models for default and prepayment. The models are ''dynamic'' in the sense that OFHEO can estimate and simulate mortgage performance in response to actual or hypothetical (e.g., stress test) changes in economic circumstances over time.

[201] At the time that data bases were constructed for this analysis, information was not available from Freddie Mac on last-paid-installment dates. Therefore, OFHEO used the ''closing date'' for Freddie Mac's defaulted loans. This is the date of disposition of a foreclosed property. The last-paid-installment date was used for Fannie Mae defaults.

[202] Note that for some loans the last-paid-installment will occur prior to the end of the sample, with no corresponding change in loan status from active to defaulted. These ''censored'' events were treated in the same manner as loans that remained active through the end of the sample period. That is, they are viewed as active up to and including the last quarter in the sample period. Note that these censored default events do not occur in sufficient numbers to have a material impact on the statistical estimates. One reason is that during those time periods and places in which the incidence of default was greatest, such as, for example, in the historical benchmark experience, foreclosure and changes in loan status occurred within several months of the last payment by the borrower. In addition, relatively complete loan histories are available for those loan origination cohorts among which the majority of default events occurred on Enterprise loans. While more recent cohorts with shorter event histories have greater potential for censoring of default events, the impact of censoring on the statistical estimates is negligible because default rates have been so low in recent years.

4. Specification of the Statistical Model

The proposed regulation employs a monthly cash flow model of Enterprise performance over a ten-year stress period. The simulation of mortgage cash flows requires conditional rates of default and prepayment to be applied to outstanding mortgage balances during each month of the stress test. The purpose of the models described in this technical supplement is to provide a means of generating the required termination rates in a manner that is reasonable for Enterprise loans under the circumstances of the stress period.

Conditional rates of default and prepayment vary depending on a variety of factors, both random and systematic, some of which are fixed at origination and others that vary over time. Characteristics of loans and borrowers at origination can affect the level and timing of mortgage default and prepayment throughout the life of the loan. For example, conditional default and prepayment rates exhibit characteristic age-profiles that increase during the first years following origination, peak sometime between the fourth and seventh years, and decline gradually over the remaining years.[203] Default and prepayment rates also vary systematically in response to economic circumstances and other factors over time, such as changes in house prices and interest rates that affect the value to the borrower of embedded options.

Like other time-or age-dependent processes, mortgage terminations are highly amenable to analysis using statistical survival-time models specified in terms of conditional probabilities of prepayment and default. Default and prepayment are ''competing risks,'' which means that the occurrence of one type of event precludes the chance to observe when the other event might have occurred, and vice versa. In such a case it is necessary to account for the joint mathematical and statistical dependence of the conditional probabilities of default and prepayment on each other. Failure to account for the competing-risks nature of the events can lead to projections of total termination

[203] *See* discussion in Schwartz and Torous, at 379 (1989).

rates (default plus prepayment) that are mathematically inconsistent and that would preclude their application in the type of actuarial calculations of cash flows required for the stress test.

As outlined above, mortgage default and prepayment result in an observed last-paid-installment, after which no further payments are forthcoming. Thus, for loans outstanding at the beginning of each time period, three mutually exclusive outcomes are possible in the model: (1) the borrower defaults; (2) the borrower prepays the loan in full; or (3) the borrower makes the scheduled loan payment, and the loan remains active and part of the event history sample for the next time period. For the purposes of the statistical analysis, each of these outcomes is interpreted as an ''event.'' This approach implies that each loan contributes potentially many observations to the event history sample, depending on how long it remains active before experiencing one of the terminal events or reaching the end of the sample period.

a. Multinomial Logit Models

OFHEO has estimated multinomial logit models for quarterly conditional probabilities of default and prepayment.[204] Several empirical studies have applied some form of the logit or similar qualitative response models to analyze mortgage prepayment and default behavior.[205] The corresponding mathematical expressions for the conditional probabilities of default ($\pi_D(t)$), prepayment ($\pi_p(t)$), or remaining active ($\pi_A(t)$) over the time interval from t to $t + 1$ are given by:

$$\pi_D(t) = \frac{e^{\alpha_D + X_D(t)\beta_D}}{1 + e^{\alpha_D + X_D(t)\beta_D} + e^{\alpha_P + X_P(t)\beta_P}} \qquad \textit{(Eq. 1)}$$

$$\pi_P(t) = \frac{e^{\alpha_P + X_P(t)\beta_P}}{1 + e^{\alpha_D + X_D(t)\beta_D} + e^{\alpha_P + X_P(t)\beta_P}} \qquad \textit{(Eq. 2)}$$

$$\pi_A(t) = \frac{1}{1 + e^{\alpha_D + X_D(t)\beta_D} + e^{\alpha_P + X_P(t)\beta_P}} \qquad \textit{(Eq. 3)}$$

Constant terms α_D and α_p, and coefficient vectors β_D and β_p, are the unknown parameters that must be estimated. $X_D(t)$ is a vector of mostly time dependent explanatory variables that are assumed to influence directly the conditional probability of defaulting (versus remaining active), and $X_p(t)$ is a vector of mostly time dependent explanatory variables assumed to influence directly the conditional probability of prepaying (versus remaining active).[206] The probability of remaining active ($\pi_A(t)$) is equal to 1 minus the other two probabilities, so that the three probabilities sum to 1.

The probabilities and coefficient vectors have a convenient interpretation when expressed in terms of odds ratios:

$$\ln\left[\frac{\pi_D(t)}{\pi_A(t)}\right] = \alpha_D + X_D(t)\beta_D \qquad \textit{(Eq. 4)}$$

$$\ln\left[\frac{\pi_P(t)}{\pi_A(t)}\right] = \alpha_P + X_P(t)\beta_P \qquad \textit{(Eq. 5)}$$

These expressions imply that the percentage impact of a one-unit change in an element of $X_D(t)$ on the relative probability or odds of defaulting versus remaining active is given by the corresponding element of the coefficient vector, β_D. A similar result holds for prepayment. Note also, that while changes in variables that affect the probability of prepayment affect the absolute level of the probability of default, and vice versa, such changes affect the probability of remaining active in a symmetric manner, so that the ''odds'' of defaulting versus remaining active are not affected.[207]

[204] The decision to model default and prepayment as quarterly events was consistent with the application of quarterly house price indexes in computing the underlying distributions of borrower equity. The resulting quarterly default and prepayment probabilities were converted to monthly factors for input to the monthly cash flow calculations required for application in the stress test.

[205] Examples of previous applications of the logit model are Campbell and Dietrich (1983), Zorn and Lea (1989), and Cunningham and Capone (1990).

[206] Some elements of $X_D(t)$ and $X_p(t)$ are constant over the life of the loan and are not functions of t.

[207] The multinomial logit model is widely applied in the analysis of consumer choice among discrete alternatives, where this feature has been called the

Continued

b. Estimation of Multinomial Logit Coefficients

The multinomial logit specification given by equations (1)–(3) is a purely mathematical representation of the underlying probabilities. How the unknown parameter coefficients of the logit model are estimated statistically depends on whether the model is applied to individual or aggregate data. Under some circumstances, the two approaches are mathematically equivalent. However, in some situations, the use of aggregate data may entail considerable loss of information.[208]

If only aggregate data were used, the proportions of loans defaulting, prepaying, and remaining active would be used to estimate the unknown coefficients α_D, α_p, β_D, and β_p directly by replacing the probabilities in equations (4) and (5) with the corresponding observed sample proportions and applying ordinary least squares. In this case the explanatory variables $X_D(t)$ and $X_p(t)$ correspond to the characteristics of the groups or classes of loans used in tabulating the observed sample proportions.

When loan-level data are available, it is possible to use equations (1)–(3) as an exact mathematical representation of the probabilities of individual loan events. In this case, estimation of unknown coefficients is achieved by the method of maximum likelihood. This approach chooses the values of α_D, β_D, α_p, and β_p that maximize the joint likelihood or probability of the entire event-history sample having actually occurred. For example, the joint sample likelihood is the product of the probabilities of each of the independent loan event observations:

$$\textit{Sample Likelihood (Joint Probability)} = \prod_{i=1}^{N} P_i \qquad \textit{(Eq. 6)}$$

where for each observation $i = 1,2. . ., N$, P_i is the estimated probability that the event that is actually observed would have occurred. These probabilities are obtained by substituting the appropriate expression from equations (1)–(3) for P_i in equation (6). The solution is found by varying the values of the elements of α_D, β_D, α_p, and β_p until the joint probability reaches its maximum value. The final values of α_D, β_D, α_p, and β_p are the maximum likelihood estimates. Numerous statistical software packages exist for this purpose.

The approach adopted by OFHEO is based on loan-level data, which has the significant advantage of preserving as much detail as possible on individual loan circumstances. This approach results in a flexible description of loan behavior, which can be used to project mortgage performance under the abnormal scenarios of the proposed regulation.

5. Explanatory Variables for Default and Prepayment

OFHEO estimated three separate sets of multinomial logit probability equations. The primary default and prepayment equations are for single family, 30-year FRMs. These loans comprise about 80 percent of all single family loans in the historical data obtained from the Enterprises. A second set of equations was estimated solely on data for ARMs. All loan types with any potential payment adjustments throughout the life of the loan were included as ARMs for purposes of the statistical estimation. A third set of default and prepayment equations was estimated to project the performance of less-prevalent single family loan types relative to 30-year fixed-rate mortgages. This estimation was performed using data on 30-year FRMs and all other fixed-rate loan types (including balloons). These loan types were grouped as: 20-year FRM, 15-year FRM, balloon, FHA/VA, and second liens. Data on 30-year FRMs are included in the estimation sample because the number of observations on other, less popular fixed-rate mortgage types was insufficient for estimating product-specific default and prepayment equations. However, the resulting default and prepayment equations are only used to project performance of the alternative product types, and not 30-year FRMs.

All three statistical estimations use the same conceptual underpinnings and empirical specifications, and only vary based on the data samples used in estimation. Thus, the basic definitions of the variables are the same across all three sets of equations, although the way some of the interest rate variable values change over time will differ, for example, for FRM loans and ARM loans, because of differences in their contractual terms.

For convenience, we refer to the three separate data sets and statistical estimations as model 1 (30-year FRMs), model 2 (ARMs), and model 3 (all fixed-rate products). In addition to the basic set of explanatory variables included in all three models, model 3 includes product-specific adjustment constants. The adjustment constants act like multipliers to the baseline default (hazard) rates of 30-year FRMs. The impacts of all other explanatory variables are presumed constant across product type, so there are no product-type adjustments to their coefficients. Because ARMs are believed to perform differently than FRMs, due to changing payments over time, they are treated in a separate estimation (model 2) so that variable coefficients can be uniquely identified for ARM versus FRM loans.

The explanatory variables $X_D(t)$ and $X_p(t)$ used to estimate the unknown coefficients of the multinomial logit models are listed in Table 31. All of the variables except mortgage age (*AGE*) were coded as categorical variables. Categorical variables are advantageous for several reasons. For instance, assigning the various explanatory variable outcomes to categories allows one to estimate effects that may be non-linear without having to experiment with many different functional forms. Because each categorical explanatory variable has minimum and maximum categories (determined through observation of the historical data), the

''independence of irrelevant alternatives.'' In the context of consumer choice theory this independence can result in apparent anomalies when close substitutes to existing choices are introduced. See, for example, McFadden (1976). This issue does not arise in the present context.

[208] For example, if the data are aggregated by taking average values of the explanatory variables within broad product groupings, then particular combinations of explanatory variables that exist for individual loans and which are associated with significant differences in probabilities of default and prepayment, will not be represented in the data. While this may not matter under ''normal'' circumstances, it could limit the usefulness of the model in projecting rates of default and prepayment within high risk categories under circumstances different than those embodied in the original aggregation scheme, such as those of the stress test.

impact of particular variables on rates of default or prepayment projected from the model is constrained to be within previous historical experience.[209] This helps to avoid unreasonable extrapolations when projecting mortgage performance under stress test conditions. Another advantage of using categorical outcomes for the explanatory variables is that it anticipates the need to apply the models to aggregated loan groups in the stress test.[210] The benefit of starting with loan-level data is that it allowed OFHEO to develop both the explanatory variables and stress test loan groups in a consistent manner, thus minimizing the loss of information due to data aggregation.

The summary of explanatory variables starts with descriptions of the two key options-related predictors of mortgage default and prepayment-respectively, the probability of negative borrower equity and the mortgage premium value. A review of additional interest rate variables and loan characteristics that are used as explanatory variables follows.

a. Probability of Negative Equity

The put option has value to the borrower when the property is worth less than the outstanding balance on the mortgage. In that case, the borrower is in a negative equity position. Thus, the equity position of the borrower is determined by the difference between the market value of the property securing the loan, $P(t)$, and the unpaid mortgage balance, $UPB(t)$:

$$EQ(t) = P(t) - UPB(t) \quad \textit{(Eq. 7)}$$

Ideally, periodic observations on the values of individual properties would be used to update individual house values and borrower equity at the same frequency (monthly) at which the decision to prepay or default can be exercised. However, because individual housing values are not updated continuously it is not possible to compute updated values of $EQ(t)$ for individual borrowers with sufficient accuracy for this measure to be used directly at the loan level.[211]

It remains possible, however, to characterize the equity positions of individual borrowers in terms of ex ante probabilities of negative equity.[212] The probability of negative equity is a function of the scheduled current loan balance and the likelihood of individual house price outcomes that lie below this value. Projected distributions of individual housing values relative to the value at mortgage origination were calculated by applying estimates of house price drift and volatility obtained from independent estimates based on the OFHEO House Price Index (HPI).[213]

The required estimates of house price drift and volatility are direct by-products of the estimation of the OFHEO HPI. The OFHEO HPI is based on a modified version of the weighted-repeat-sales (WRS) methodology (Case and Shiller, 1987, 1989), and is consistent with the assumption that housing values are generated by a log-normal diffusion process. This means that over time individual housing values will appreciate at different rates, distributed randomly around the average rate of appreciation. Over time, the cumulative rates of appreciation for individual homes will become more and more dispersed or diffused, hence the reference to diffusion processes. Mathematically, individual house prices are assumed to obey a non-stationary log-normal diffusion process in which individual house price appreciation since mortgage origination is normally distributed with variance σ^2 (A) around the expected rate of appreciation from the HPI, $\beta(t)$, computed as:

$$\beta(t) = ln\left(\frac{HPI(t)}{HPI(0)}\right) \quad \textit{(Eq. 8)}$$

Where A is loan age (in quarters), and HPI(0) is the value of the HPI at time of loan origination.[214] For the individual borrower with original house price $P(0)$ at time 0, the probability of negative equity at time t, PNEQ(t) is given by:

[209] This constraint applies specifically to the marginal contribution of particular explanatory variable outcomes, not to the overall level of the default and prepayment probabilities projected by the model. For example, if several explanatory variables simultaneously take on values that have not been previously observed in combination, then it is possible that the projected probabilities of default or prepayment would exceed those observed in the historical data. This type of outcome is anticipated by the 1992 Act, which requires regional adverse credit conditions to apply nationally to all loans at the same time.

[210] The loan groups used in the stress test were developed in conjunction with the classification of explanatory variable outcomes in the statistical analysis of mortgage default and prepayment. Aggregation of mortgage assets in the stress test recognizes the need to classify assets within broad product categories for financial accounting. Within the context of the proposed regulation, the use of aggregate loan groupings also facilitates the assignment of new loan products to existing categories with known risk characteristics. Further explanation of the aggregate loan groups used in the stress test is in section III. A., Mortgage Performance of the preamble.

[211] As discussed above, given the measurement difficulties associated with borrower equity at the loan level, some researchers have used various means of simulating the distribution of borrower equity. For example, Foster and Van Order (1984, 1985) used a Monte Carlo simulation of a synthetic mortgage pool in conjunction with a house price diffusion process and actual default and prepayment rates to reconstruct a time-series for the number of borrowers in a negative equity position. Under additional restrictions on the model (i.e., that only borrowers with negative equity default, and only borrowers with positive equity prepay), the time-series for the number of borrowers with negative equity (various levels) was used in regressions for conditional default and prepayment probabilities.

[212] See the discussion of ex ante probabilities of negative equity in footnote 199.

[213] House price drift is defined here as the average rate of house price appreciation as determined by the appropriate market house price index, while volatility is defined as the variance in individual house price appreciation rates around the market average rate of appreciation.

[214] Estimates of expected appreciation or drift in house prices are obtained directly from the estimated values of the HPI for each of the nine U.S. Census divisions. Estimates of diffusion volatility, $\sigma^2(A)$, are computed using the estimated parameters for the error variance of individual log-differences in housing prices that are obtained from the second-stage of the WRS method for each division. See Calhoun (1996) for additional details. Deng, Quigley, and Van Order (1996) applied a similar approach using WRS indexes for 26 metropolitan areas estimated using Freddie Mac data.

$$PNEQ(t)=Pr\{EQ(t)<0\} \qquad (Eq.\ 9)$$

$$= \Phi\left\{\frac{ln(UPB(t))-ln\ (P(0)e^{\beta(t)})}{\sigma(A)}\right\} \qquad (Eq.\ 10)$$

where $\Phi(x)$ is the standard normal cumulative distribution function evaluated at x. This expression quantifies the relationship between changes in house prices on average, and the likelihood of negative appreciation on individual properties that places some fraction of borrowers in a negative equity position. The imputed share of borrowers with negative equity implied by equation 10 is used as a proxy for the probability of negative equity for an individual borrower.[215] The computed probabilities of negative equity are assigned to one of eight categorical outcomes, as summarized in Table 31.

b. Relative Spread

The theoretical value of the call (prepayment) option on a mortgage is a function of the difference between the present value of the future stream of mortgage payments discounted at the current market rate of interest, $R(t)$, and the present value of the mortgage evaluated at the current note rate, $C(t)$. The actual value of this call option to the borrower is unknown due to uncertainty over the future time path of mortgage payments associated with uncertain future probabilities of prepayment and default. Therefore, it is common to use other variables to capture the impact of the call option value on prepayment rates. Following recent work by Deng, Quigley and Van Order (1996), OFHEO approximated the call option value using the relative spread variable, RS(t):

$$RS(t) = \left\{\frac{C(t)-R(t)}{C(t)}\right\} \qquad (Eq.\ 11)$$

Positive values of the call option exist when the mortgage coupon exceeds the current market interest rate (positive spread), and the borrower can benefit financially by refinancing to obtain a lower interest rate. Outcomes for the relative spread variable are classified into seven categorical outcomes, as summarized in Table 31.

c. Prepayment Burnout

Recent studies of mortgage terminations have emphasized the importance of previous interest rate environments for distinguishing among borrowers more or less likely to exercise the prepayment option when the opportunity arises.[216] The tendency for the most responsive borrowers to prepay first, so that the remaining sample of borrowers are those with lower average conditional probabilities of prepayment, contributes to the observed seasoning or ''burnout'' of mortgage pools. The indicator variable $B(t)$ is included to measure whether the borrower has missed a previous refinance opportunity.[217] $B(t)$ is defined by whether the market rate of interest was 200 basis points or more below the coupon rate of the mortgage during two or more quarters over the past two years. Those who have missed previous refinance opportunities are predicted to have lower conditional probabilities of prepayment and higher conditional probabilities of default. Failing to refinance under favorable interest rate conditions may indicate the existence of other credit-related problems, such as failure to obtain an adequate property appraisal.[218]

d. Yield Curve Slope

Expectations about future interest rates and differences in short-term and long-term borrowing rates associated with the slope of the Treasury yield curve influence the choice between ARM and FRM loans and the timing of refinancings and prepayments. A high value for the slope of the yield curve indicates relatively favorable short-term rates, increasing the likelihood that a borrower refinances to an ARM to take advantage of the lower initial coupons that can be offered by lenders. The variable $YS(t)$ is included to measure the current slope of the yield curve. This variable is computed as the ratio of the ten-year Constant Maturity Treasury yield (CMT) to the one-year CMT, and assigned to four categorical outcomes.

e. Mortgage Age

The existence of other demographic and economic processes that may ''trigger'' mortgage default or prepayment, and the inability to measure the diffusion of house prices and the distribution of borrower equity precisely, create a need to account directly for age-specific differences in conditional rates of default and prepayment.[219] The direct dependence of the conditional probabilities on mortgage age recognizes the existence of other borrower processes and unobserved heterogeneity that induce duration dependence in the conditional rates of termination and help to explain the typical age patterns of default and prepayment.[220] For this reason, mortgage

[215] Although the market level (regional) values of house price drift and volatility are used, the imputed probability of negative equity is still specific to the individual borrower's circumstances, since the loan-specific values of original LTV and loan amount are used in the calculations.

[216] For example, see the discussions of borrower heterogeneity and path dependence in Bartholomew, Berk, and Roll (1988), and the discussion of burnout in Richard and Roll (1989).

[217] The indicator variable equals one if the spread between the note rate on the mortgage and the quarterly average market rate of interest has been 200 basis points or greater during any two of the past eight quarters.

[218] See footnote 198.

[219] Under a pure options model, the typical age patterns of conditional default and prepayment rates might be attributed entirely to the diffusion of housing values and the introduction of unobserved differences (heterogeneity) in the equity positions of individual borrowers, resulting in differences in the rates of default and prepayment among particular subsets of individual borrowers. As these differences emerge following mortgage origination, the observed average conditional default and prepayment rates will initially increase. Eventually, as ''high risk'' borrowers depart the sample or mortgage pool, the average conditional rates of default and prepayment will decline.

[220] *See* Lancaster (1990) for a discussion of the impact of unobserved heterogeneity on estimates of

age (*AGE*) is included as an additional explanatory variable in the empirical model. The model utilizes a quadratic function of mortgage age, where age is defined as the number of quarters since origination. The use of a parametric function of age instead of categorical values is based on two considerations. First, the use of categorical age values for individual quarters would result in a large number of additional coefficients to estimate. Combining loans into broader age groupings to reduce the number of parameters can produce large differences in rates of default and prepayment with small increments in age for loans graduating from one age category to the next. Second, when individual age categories are used, they show that a quadratic age function is a reasonable assumption, at least for the first eight to ten years. At higher values of mortgage age, the samples are much smaller (most loans have terminated by these ages), with the result that the estimates for individual age categories are quite erratic due to sampling error. The use of a simple functional form like the quadratic helps to smooth the estimates of the age effects for the higher age groups.

f. Original LTV

The original LTV ratio, *LTV*(0), serves as an indicator of the income and net worth of the borrower at mortgage origination, and directly determines the initial equity position of the borrower. To the extent that income and wealth are negatively correlated with *LTV*(0), high LTV borrowers will have fewer economic resources to finance the transactions costs of prepayment or endure spells of unemployment or other trigger events that might otherwise cause them to exercise the default option in a sub-optimal manner. Finally, high LTV borrowers have already demonstrated a willingness to ''leverage'' the financing of the home purchase, which may portend a greater sophistication or ''ruthlessness'' in the exercise of the default option. Thus, one would expect higher rates of default and lower rates of prepayment as *LTV*(0) increases. The six *LTV*(0) categories used in the default/prepayment models are similar to those used by the Enterprises in their annual reports and information statements.

g. Season of the Year

The variable *SEASON*(*t*) was included to account for the current season (quarter) of the calendar year, in recognition of the potential impact of weather, school schedules, and seasonal employment patterns on residential mobility and default and prepayment probabilities.

h. Occupancy Status

OS is an indicator variable included to distinguish mortgages on owner-occupied units from investor loans. Owner occupants should be less likely than investors to exercise the default option given the direct benefits they receive from the consumption of housing services. Owner occupants should be more likely to prepay than investors for non-financial reasons such as residential mobility.

i. Relative Loan Size

The ability to bear the transactions costs of refinancing, or to weather economic stress and avoid default, will be correlated with the income level of the household. Given the lack of information in the historical data on household income at origination, a measure of relative loan size provided a proxy for the relative income level of the household. *LOANSIZE* was defined as the ratio of the original loan amount relative to the average-sized Enterprise loan originated in the same State during the same origination year.[221]

j. Product Type Indicators

Five product type indicators were created to account for the performance of non-standard loans relative to the standard 30-year FRM loans in model 3: 20-Year FRM, 15-Year FRM, balloon, FHA/VA, and seconds. These indicator variables provide the adjustment constants mentioned earlier.

k. ARM Coupon Rate Dynamics

To estimate the current values of both the probability of negative equity, *PNEQ*(*t*), and the relative spread, *RS*(*t*), variables for ARM loans, it was necessary to trace the path of current coupon rates over the active life of individual mortgages. For standard ARM products, the coupon rate resets periodically to a new level that depends on the underlying index, plus a fixed margin, subject to periodic and lifetime interest rate caps that specify the maximum and minimum amounts by which the coupon can change on any one adjustment and over the life of the loan.[222] ARM coupon rates are updated using the following formula:

$$C(t) = \max\{\min[Index(t-S) + Margin, C(t-1) + A(t)\cdot PeriodUpCap, \quad \text{(Eq. 12)}$$
$$C(0) + A(t)\cdot LifeUpCap], C(t-1) - A(t)\cdot PeriodDownCap(t),$$
$$C(0) - A(t)\cdot LifeDownCap\}$$

Where *Index (t*) is the underlying index value at time *t, S* is the ''lookback'' period, and *Margin* is the amount added to *Index* (*t—S*) to obtain the ''fully-indexed'' coupon rate. The periodic adjustment caps are given by *PeriodUpCap* and *PeriodDownCap*, and are multiplied by an indicator variable *A*(*t*) which equals zero except during scheduled adjustment periods. The maximum lifetime adjustments are determined by and *LifeUpCap* and *LifeDownCap*.[223]

duration dependence in econometric models of transition probabilities. Other borrower processes include residential mobility, employment mobility, involuntary unemployment, and demographic events related to household formation and dissolution, mortality, and fertility. Ideally, given suitable household-level data, these other processes would be modeled jointly with mortgage terminations.

[221] Price Waterhouse (1990) reported significant differences in claim rates for FHA mortgages stratified by loan size. Smaller loans were observed to fail at significantly higher rates than other loans.

[222] Detail on specific ARM contracts was obtained in some cases from loan-level information, and in other cases was obtained using plan-level detail for loans in certain ARM product categories. Any loan product with variable interest rates was classified as an ARM, and modeled according to product terms. This includes so-called two-step mortgages and mortgages with interest-rate buydowns. For simplicity, the margin was set at 2 percent for all ARMS.

[223] The majority of Enterprise ARM loans are indexed to the one-year Treasury rate, with smaller but significant numbers indexed to either the five-year or ten-year Treasury rate, the 11-District Cost of Funds Index (COFI), or the London Inter-Bank Offer Rate (LIBOR). A small percentage of ARM loans are indexed to the six-month or three-year Treasury rates. The majority of ARM loans had lifetime adjustment caps of five or six percent, and have no lifetime rate floors. Most have periodic rate adjustment caps of two percent, while some have periodic rate adjustment caps of one percent. The majority of ARM loans have adjustment frequencies of one year, while a significant minority are adjusted every six months.

6. Empirical Results

The three models were estimated by the method of maximum likelihood using the SAS® CATMOD procedure. The CATMOD procedure employs a design matrix that automatically converts all categorical variables to a series of indicator variables prior to estimation. As discussed above, all explanatory variables except mortgage age were converted to indicator variables. This allows one to reduce the data to a smaller number of loan records, each representing unique combinations of the categorical variables, to which a frequency count is assigned and applied as a sampling weight in subsequent statistical analyses. This approach avoids the need to undertake choice-based sampling (e.g., over-sampling of defaulted loans) in order to assure that sufficient numbers of rare events like mortgage default are obtained.[224] However, given the large number of loan level observations available to OFHEO, simple random samples were used to estimate the 30-Year FRM and Multiple Products models. All available data were used to estimate the ARM model.[225]

Table 32 contains the parameter estimates for the three models.[226] The constant and age parameters are listed first, as they provide a baseline function to which the effects of other variables can be added. There is a high level of consistency in the coefficient estimates across all three models, and all three models provide empirical support for the importance of the options-related variables.

The coefficient estimates for the probability of negative equity variable (*PNEQ*) vary on the same order of magnitude for default as the coefficient estimates for the original LTV variable. *PNEQ* is also important for prepayment, in the opposite direction, consistent with the expectation that those most likely to have negative equity will have the greatest difficulty selling their homes or refinancing their mortgages, and therefore be less likely to prepay their existing mortgages. Original LTV is relatively unimportant for prepayment, although those in the lowest LTV category are more likely to prepay.

The value of the call option measured by the relative spread (*RS*) shows quite large effects on prepayment in the hypothesized direction. The higher the coupon rate on the mortgage relative to the current market rate of interest the higher the likelihood of prepayment. Note the general similarities between the *RS* coefficient estimates for models one and two (30-year FRMs and ARMs). Because ARM coupon rates will adjust with changes in market rates, ARM borrowers are less likely than FRM borrowers to end up with large positive or negative *RS* values. However, the estimates in Table 32 imply that ARM and FRM borrowers behave in a similar manner under comparable values of the call option.

The prepayment burnout variable, *B,* is most important for default rates, and indicates that missed opportunities to prepay are associated with higher credit risk. This result reinforces the results discussed above for *PNEQ*, where higher values of *PNEQ* were associated with lower probabilities of prepayment. This result also reflects the lack of precision in measurements of borrower equity at the loan level.

The slope of the yield curve (*YS*) is important for the probability of prepayment for FRM borrowers, especially for steep positive values of the slope. This result is consistent with the tendency of borrowers to refinance to ARM mortgages when short-term rates are relatively low and lenders can offer very favorable initial coupons (''teaser'' rates). It is also consistent with the assumption that the expectation of higher interest rates in the future may cause some borrowers to refinance sooner to lock in lower rates. The yield curve slope variable has similar, but smaller, effects for ARM borrowers.

The *SEASON* variable has modest effects in the anticipated directions. For FRM borrowers, prepayment rates are lower than average in the Winter and higher in the Spring. Default rates are lower in the Winter and higher in the Fall. For ARMs, prepayments are also higher in the Fall, but defaults are lower in that season.

Occupancy status (*OS*) has much larger impacts on default probabilities for ARM borrowers than FRM borrowers. For both product types, investors are more likely to default than owner-occupants, and much more so for ARM borrowers than FRM borrowers. It is reasonable to expect that owner-occupants will be less ruthless in the exercise of the default option given the offsetting value they receive from living in the home. The prepayment effects are more similar across ARM and FRM borrowers.

The variable *LOANSIZE* was included as a proxy for borrower income at origination. The results in Table 32 indicate that relative loan size is not particularly important for default probabilities, at least after controlling for the other explanatory variables. *LOANSIZE* is much more important for prepayment, with smaller loans prepaying at lower rates than relatively large loans. This is consistent with the interpretation of *LOANSIZE* as a proxy for borrower income. Lower income borrowers may lack the resources to bear the transactions costs of refinancing, causing them to prepay at lower rates than higher income borrowers with relatively large loans. Lower income borrowers may also be less mobile than higher income borrowers. The results for prepayment are similar across FRM and ARM borrowers.

The results for the two fixed-rate models, models one and three, are generally quite consistent. The individual product type indicators in model 3 provide estimates of the relative rates of default and prepayment of various fixed-rate products in comparison to 30-Year FRMs, and in comparison to each other. Balloon mortgages have the highest rates of default and prepayment relative to 30-Year FRMs. Intermediate FRM products (15-Year and 20-Year) default at lower rates than 30-Year FRMs. This result is consistent with more rapid loan payoff and accumulation of borrower equity for these borrowers. Rates of prepayment on intermediate FRMs are comparable to those on 30-Year FRMs. FHA and VA loans have higher rates of default and lower rates of prepayment than 30-Year FRM loans. Results for the category of second loans is most similar to the FHA/VA loans.

7. Application of the Models in the Stress Test

The three product-based single family models provide the means to project the conditional default and prepayment probabilities required as inputs to the cash flow model of Enterprise financial

[224] It has been demonstrated for static logit models that choice-based sampling results in biased estimates of the coefficients of the logit constant terms, for which relatively simple corrections are available, based on the population distribution of the explanatory variables across groups defined by dependent variable outcomes (Costlett, 1981). It is not clear that the same form of correction applies to the retrospective event-history sample used in this analysis. Selection on the basis of default outcomes implies selection of an array of preceding ''non-events'' for each quarter the loan was active, so that the distributions of the explanatory variables for specific age categories depends on the timing of default events for individual loans.

[225] A ten-percent random sample was used for the 30-Year FRM model and the Multiple Products model. All data used for estimation were subject to a variety of data quality screens and available data for all the explanatory variables.

[226] Note that a particular feature of the SAS CATMOD procedure is that when it estimates the coefficients corresponding to a variable with N categories, the program estimates only the first N–1 coefficients. The final-category coefficient for each variable is computed as the additive inverse of the first N–1 category coefficients.

performance. The stress test aggregates single family loan-level data into loan groups based on the following characteristics: Enterprise, portfolio (securitized vs. retained), product type, origination year, original LTV ratio class, original coupon class, starting coupon class, and region (Census division). The information contained in characteristics data for each aggregated loan grouping is sufficient, when combined with data on house price growth rates and interest rates, to compute and update all of the explanatory variables needed for computing conditional default and prepayment probabilities during the stress period.

There are three exceptions to this general statement. The variables *SEASON* and *LOANSIZE* were not used to classify loans for the purpose of the stress test. The *SEASON* variable was excluded when applying the logit models to project default and prepayment probabilities over the stress period.[227] The *LOANSIZE* variable was retained, but all loans were categorized as being of average size. These two changes reduced by a factor of nine the number of loan groups that had to be processed when running the stress test. Accounting for seasonal effects and differences in default and prepayment rates by loan size was not considered essential for projecting mortgage performance in the stress test.[228] In addition, the variable *OCCUPANCY*, used to distinguish mortgages on owner-occupied units from investor loans, is replaced by the portfolio average percentages for each occupancy status. Thus, instead of creating separate loan groups for owner-occupied and investor loans, these loans are combined into a single group, and a weighted average of the logit coefficients for owners and investors is used when projecting default and prepayment probabilities. This procedure reduces the number of records that must be processed by a factor of 2, but still allows OFHEO to account for changes over time in the percentage of Enterprise mortgages that are investor loans.

The detail contained in the starting position loan group records is sufficient to treat each loan group as if it performs like a single loan, with the projected probability of default or prepayment from the model corresponding to the share of the loan group balance that will default or prepay in any given period (i.e., by the ''law-of-large-numbers''). Group-specific average values of original LTV and mortgage coupon are used in place of exact loan-specific values in computing explanatory variables requiring these as inputs (e.g., *PNEQ* and *RS*). Categorical values such as original LTV and region (Census division) are classified in the same way for both the loan-level data used for estimation and the loan groupings used in the stress test.

Another nuance of stress test implementation is that, for purposes of projecting default and prepayment rates, OFHEO treats all mortgages with variable payments as if they were standard one-year Treasury ARMs, with identical payment caps and interest rate margins. In contrast, in the statistical analysis, specific payment changes for each loan type were reflected in the creation of explanatory variables.

In the development of explanatory variables for both the statistical analysis and stress test implementation, a shortcut is used to amortize ARMs. At each payment adjustment date, the new mortgage payments are computed using updated interest rates but with the original UPB and loan term, rather than current UPB and remaining term. This is seen in the formula used for PMT_q, which is the same for both fixed- and adjustable-rate mortgages. (*See* section 3.5.2.3, Procedures of the Appendix.) This approach provides an approximation for actual payment changes on adjustable rate mortgages. It expedites calculations by reducing the code necessary to update payments and UPB in each quarter. The approximation here should have little effect on default rate results because of the use of categorical, rather than continuous explanatory variables. Differences in loan amortization arising from using this payment-calculation approximation only affect default or prepayment rates when those differences move the probability of negative equity variable from one (value) category to another. Loan amortization in the Cash Flow component of the stress test does not use this shortcut.

In the development of variables for both the statistical analysis and stress test implementation, the incorrect term is used to amortize balloon loans. Mortgage origination term (T_0), rather than mortgage amortization term (T_a), is used to amortize these loans. This is seen in the formula used for PMT_q, which does not distinguish between balloon loans and other loan products. See section 3.5.2.3, Procedures of the Appendix. Amortization of balloon loan products in the Cash Flow component of the stress test uses the mortgage amortization term.

8. Consistency With the Historical Benchmark Experience

Certain adjustments and assumptions to the models were made to assure consistency of the rates of default projected in the stress test with the BLE. Loan-level data from the benchmark was aggregated in the same way current Enterprise loan groups are formed in the stress test, and the 30-year FRM model was applied to these data to project conditional and cumulative default and prepayment rates for the ten years following origination.[229] A single set of house price appreciation rates from the OFHEO HPI, the ten-year sequence of appreciation rates from the West South Central Census division for the period from 1984 Q1 to 1993 Q4, was applied to every benchmark loan group.[230] Actual historical interest rates were used. The projected average ten-year cumulative default rate was compared to that observed for the BLE, and adjustments were made to the constant term α_D of the default function until the projected and observed default rates were equal.[231]

[227] The parameter estimates generated by the SAS CATMOD procedure are defined so that they sum to zero across all categories of a given explanatory variable. This implies that dropping them from the model is equivalent to assuming that the logit probabilities for default and prepayment include the average effect across all the possible categories of the excluded variable.

[228] Including the *SEASON* variable in estimation can be justified because it helps to isolate the statistical impact of changes in house prices on borrower equity from purely seasonal fluctuations in default and prepayment rates. Likewise, *LOANSIZE* and original LTV are both likely to be related to borrower income and wealth at mortgage origination. However, because *LOANSIZE* is defined relative to the average sized loan within a state in the year of origination it provides a somewhat different measure of relative income or wealth.

[229] Note that all loans of the BLE are newly originated loans.

[230] The West South Central Census Division does not exactly match the 4-State benchmark region, but its use here to represent benchmark economics is consistent with OFHEO's proposal to aggregate data based on Census divisions, and to apply historical Census division-level house price growth rates to season loans at the beginning of the stress test. What is most important is that the price series used to calibrate the statistical equations is the same series that will be used in the stress test itself. The actual ten-year house-price experience of the West South Central Division and the 4-State benchmark area, 1984–1993, are very similar.

[231] When computing the cumulative default rate projected by the model for comparison with that observed for the benchmark experience, the same calculations were used. The model was used to project the total defaulting UPB for benchmark loans over the ten-year period following origination for each monthly origination cohort. The total defaulting UPB for each Enterprise was obtained by summing up the total defaulting UPB for each origination cohort, which was divided by the total original UPB for that Enterprise to compute the ten-year cumulative default rate. The two Enterprise cumulative default rates were then averaged. As discussed in NPR1, because of missing data on defaulting loans, OFHEO used the original UPBs on default loans in place of UPB at the time of default.

Continued

The adjusted (calibrated) model is then applied in the stress test, along with the sequence of house price appreciation rates used in the calibration procedure.[232] Therefore, if newly originated loans with characteristics similar to those comprising the benchmark sample were subjected to the same economic circumstances as occurred in the benchmark experience, then the statistical model of mortgage performance would project ten-year cumulative default rates equal to those of the benchmark sample. Conversely, to the extent interest rates, property values, and loan characteristics are different from the benchmark sample, and to the extent adjustments are necessary to account for other statutory requirements (e.g., increased general inflation under large increases in the ten-year CMT), the stress test rates differ from the benchmark level.

The adjustment of the model is appropriate for use in the stress test because the statistical equations in the model were estimated using Enterprise data on loans from a broad range of times and places, in addition to those loans included in the benchmark sample. Because, by definition, the BLE reflects the highest rates of loss observed from among these other periods and places, the model would not be likely to replicate benchmark results on benchmark loans exactly without some type of adjustment.

The calibration procedure does not add an adjustment factor to match projected prepayment rates directly to the benchmark prepayment experience. Nevertheless, the stress test model is fully calibrated to the credit loss experience of the benchmark loans because the calibrated default equation, and the uncalibrated prepayment equation that was used to help calibrate the default equation, are used together to determine mortgage performance. Because the time paths of Treasury yields and mortgage rates used in the calibration were those corresponding to the individual benchmark origination cohorts, the conditions leading to prepayments in the calibration exercise are entirely consistent with the benchmark default experience.

This has little effect on the resulting historical loss rates, because the same values for defaulting UPBs were used when computing severity rates. In the calibration of default rates, the UPBs at the time of default projected from the model (which take into account normal amortization) were adjusted back to their origination values for consistency with the benchmark methodology.

[232] In the calibration, all loans of the BLE are assigned an HPI volatility parameter estimate based on the West South Central Census division. In the stress test, loans from each region retain their respective regional volatility values.